COAL MINING AND RECLAMATION PERMIT
APPLICATION TO REVISE A PERMIT (ARP)

Issued To: AMERICAN ENERGY CORP
43521 Mayhugh Hill Rd.
Twp Hwy 88
Beallsville, OH 43716

Telephone: (740) 926-9152

ARP Type:
Remove a Condition of Permit
Revise Subsidence Control Plan

Permit Number: D-425
Application Number R-425-17

Effective: 04/17/2007
Expires: 10/21/2009

The issuance of this ARP means only that the application to conduct a coal mining operation meets the requirements of Chapter 1513 of the Revised Code, and as such DOES NOT RELIEVE the operator of any obligation to meet other federal, state or local requirements.

This ARP is issued in accordance with and subject to the provisions, conditions, and limitations of Chapter 1513 of the Revised Code and Chapters 1501:13-1, 1501:13-3 through 1501:13-14 of the Administrative Code.

The approved water monitoring plan for this ARP is:

Quality: N/A
Quantity: N/A

Note: Any previous condition(s) imposed on this permit, or subsequent adjacent areas, also apply to this ARP unless noted otherwise.

Signature: Scott R Kell **Date:** 04/17/2007
Chief, Mineral Resources Management

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F100 Rev: 07/01/2001

AEC 19743

_____ New Submittal
_____ Revised Submittal R- 425-17

OHIO DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINERAL RESOURCES MANAGEMENT

APPLICATION TO REVISE A COAL MINING PERMIT

Note: Refer to the division's "General Guidelines for Processing ARPs" and "Requirements for Specific Types of Common ARPs" for guidance on submitting and processing ARPs.

1. Applicant's Name **American Energy Corporation**

   Address **43521 Mayhugh Hill road**

   City **Beallsville** State **Ohio** Zip **43716**

   Telephone Number **740.926.9152**

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DIVISION OF MINERAL RESOURCES MANAGEMENT

2. Permit Number **D-0425**

3. Section of mining and reclamation to be revised:

   Subsidence Mitigation Part 3,K(5) (6) (7)

4. Describe in detail the proposed revision and submit any necessary drawings, plans, maps, etc:

   To lift the subsidence condition of D 425-5

5. Describe in detail the reason for requesting the revision:

   To obtain permission to subside structures in the shadow area by submitting a report from Dr.Yi Luo.

6. Will this revision constitute a significant alteration from the mining and reclamation operations contemplated in the original permit? ☐ Yes, ☒ No.
   (**Note:** refer to paragraph (E)(2) of 1501:13-04-06 of the Ohio Administrative Code to determine if a revision is deemed significant.)

   If "yes," complete the following items 7 through 9.

7. In the space below, give the name and address of the newspaper in which the public notice is to be published.

   NA

8. In the space below, give the text of the public notice that is to be published. (Include the information required by paragraph (A)(1) of 1501:13-05-01 of the Ohio Administrative Code.)

   NA

Revised 03/06
DNR-744-9003

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7. In the space below give the name and address of the newspaper in which the public notice is to be published.

8. In the space below give the text of the public notice that is to be published. (Include the information required by paragraph (A)(1) of 1501:13-05-01 of the Ohio Administrative Code.)

9. In the space below give the name and address of the public office where this application is to be filed for public viewing.

I, the undersigned, a responsible official of the applicant, do hereby verify the information contained in this revision request is true and correct to the best of my information and belief.

JAMES R TURNER, JR

Print Name

Date 10-24-05

Signature

Title TREASURER

Sworn before me and subscribed in my presence this 24th day of October, 2005

BARBARA L. RUSH
NOTARY PUBLIC, STATE OF OHIO
MY COMMISSION EXPIRES 9-08-09

NOTARIAL SEAL
STATE OF OHIO

Barbara L. Rush
Notary Public

FOR DIVISION USE ONLY

This request is hereby APPROVED.

Chief, Division of Mines and Reclamation

Date 4-17-07

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I attest that the methodology and findings presented in this report are based upon the currently accepted principles of mining engineering. Specifically, the subsidence prediction and modeling methods used in the report have been developed and calibrated through years of research and applications on similar structures.

Yi Luo, Ph.D., P.E.
Associate Professor
Department of Mining Engineering
College of Engineering and Mineral Resources
West Virginia University
Morgantown, WV 26506

Under temporary authorization (based on application to register by comity in the State of Ohio, dated January 11, 2007) which will expire on March 19, 2007.

Signature: ____________ January 24, 2007

YI LUO
REGISTERED
15073
STATE OF
WEST VIRGINIA
PROFESSIONAL ENGINEER

Registration No. and Seal: WV 15073

State of Ohio: Temporary Permit Granted on January 19, 2007

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Assessment and Mitigation of Subsidence Influences on Tower Structures Affected by Longwall Mining Operations

By

Yi Luo, *Ph.D., P.E., Research Associate Professor*
Syd S. Peng, *Ph.D., Professor and Chairman*
Department of Mining Engineering
West Virginia University

INTRODUCTION

In the new permit area of the American Energy Corporation's Century Mine (Permit application No.: D-0425-5), the planned longwall mining operations will be conducted under a number of municipal and industrial structures. These structures include: (1) one steel water tower, (2) 14 4-leg steel lattice towers for an electrical power transmission line, (3) two guyed steel towers for telecommunications. The first author visited the sites on July 19, 2005 and obtained the necessary mine maps.

This report presents the methods for assessing and mitigating the potential subsidence influences on these tower structures caused by the planned longwall operations in the permit area.

SITE AND STRUCTURES

Surface and Mine Layout

Figure 1 shows the site where the main structures are located. The water tower and a larger communication tower are located on the top part of the figure while the smaller cell tower and the power transmission line are on the lower part of the figure. At the time of the site visit, the mining company has also considered to lay out the longwall panels in a different way to place some of the main structures (i.e., water towers, and guyed telecommunication towers) over the central portions of the longwall panels so that they will not subject to permanent surface deformations caused by the mining operations.

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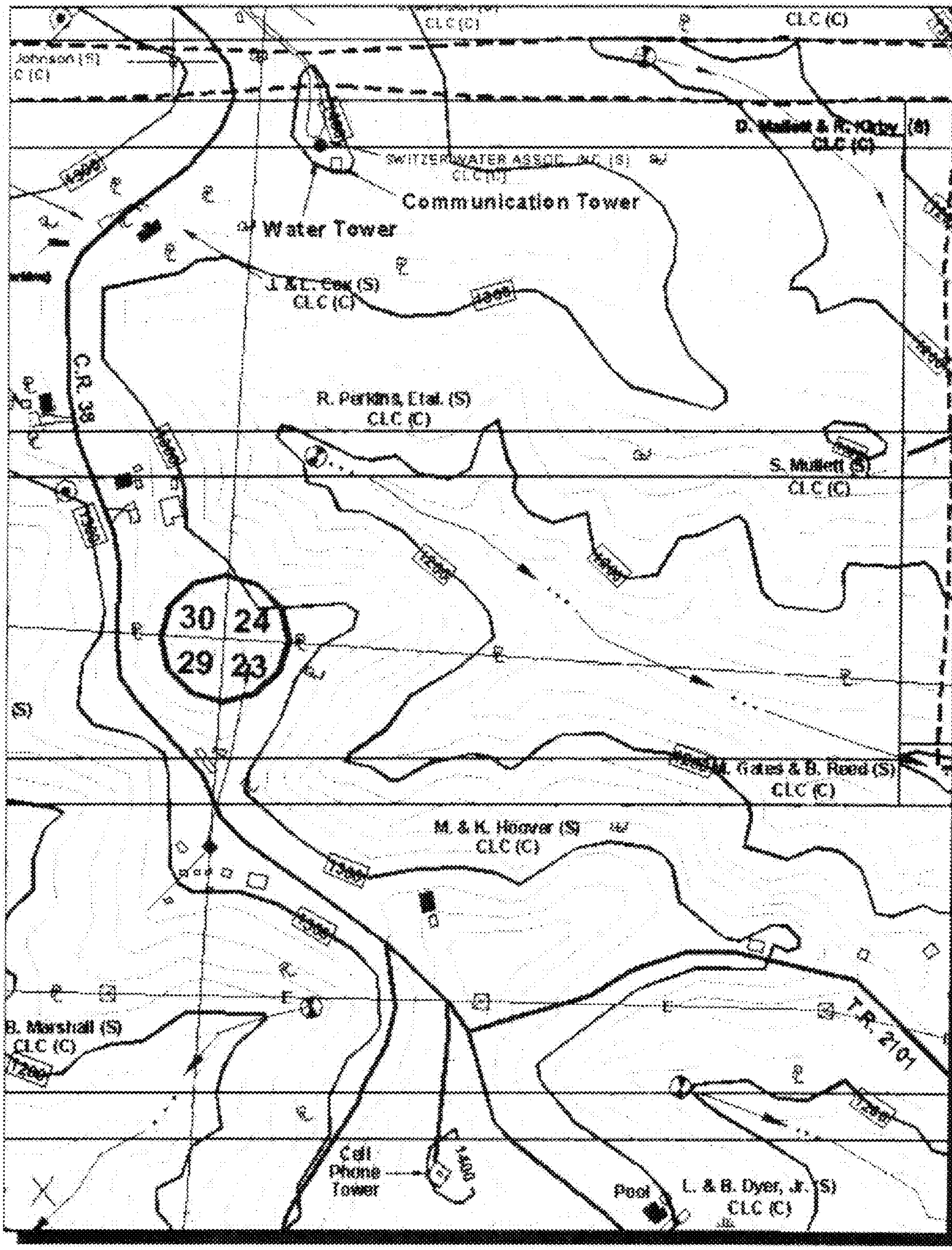

Fig. 1 Area with the Main Structures

The gentle hilly surface topography in the area is also shown in Fig. 1. The overburden depth at the locations of the tower structures ranges from 460 ft to 745 ft. The rib-to-rib width of the longwall panels is 920 and the width of the three-entry chain pillar system between adjacent longwall panels is about 140 ft.

Main Structures

The main structures in the permit area include: (1) one steel water tower, (2) 14 4-leg steel lattice towers for an electrical power transmission line, (3) two guyed steel towers for wireless telecommunications.

Figure 2 shows the water tower. It is located on the top of a gentle hill. The tower is a steel cylindrical structure sitting on a concrete base. The cylindrical tank is about 50 ft tall and 14 ft in diameter and has a holding capacity of 54,000 gallons. The concrete base under the tank is about 15 ft in diameter and between 3 and 4 ft thick (Fig. 3). The outer layer of the steel sheet that was used to construct the water tank is about 3/16" thick.

Figure 4 shows the larger communication tower. It is located a short distance away from the water tower on a gentle slope. The height of the tower is about 300 ft. The tower is a guyed steel lattice tower with the guy wires tied at five different levels on the tower. Three guy wires are used at each tie level. Therefore, guy wires permit the main tower structure to rotate in the horizontal plane to certain degree. The base on the tower (Fig. 5) is bolted to the concrete foundation with one bolt to allow horizontal rotation. The guy wires are tied to the ground at three anchor locations (Fig. 6) that are spaced 120° apart from the base. Pole type antennae are mounted on the top of the tower.

Figure 7 shows the small cell phone tower located on the top of another gentle hill. It is also a guyed steel tower and is about 150 ft high. The guy wires are tied to the main tower structures at three different levels. At the lower two levels, three guy wires are used at each tie level. On the top level, six guy wires, two on each direction, are used to restrict the horizontal rotation of the tower structure (Fig. 8). The base of the tower is the same of the larger tower. On the ground, three anchors are buried about 120° apart from the tower base. Four dish type antennae are mounted on the top of the tower and another dish antenna at middle level.

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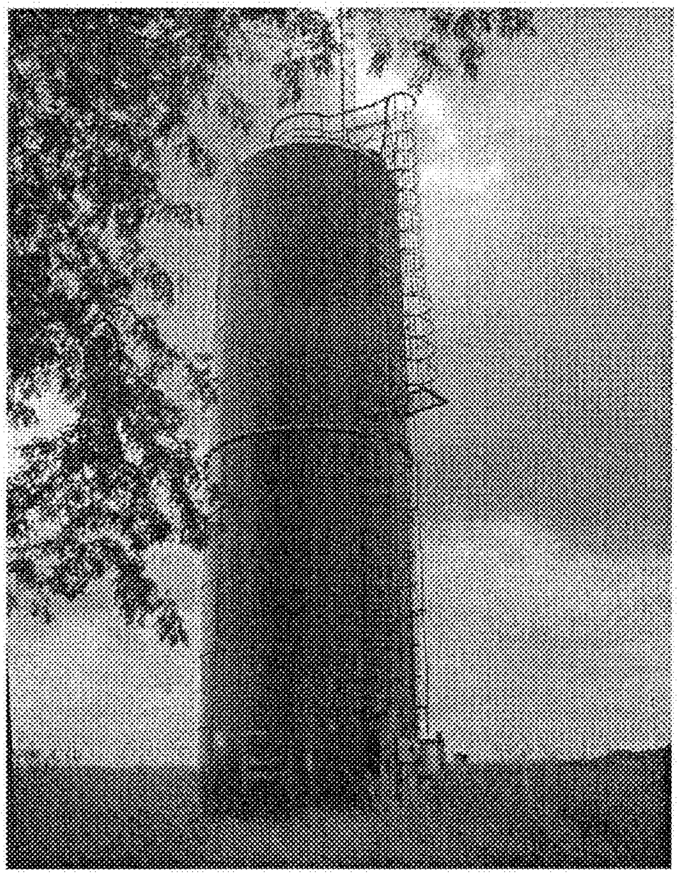

Fig. 2 Municipal Water Tower

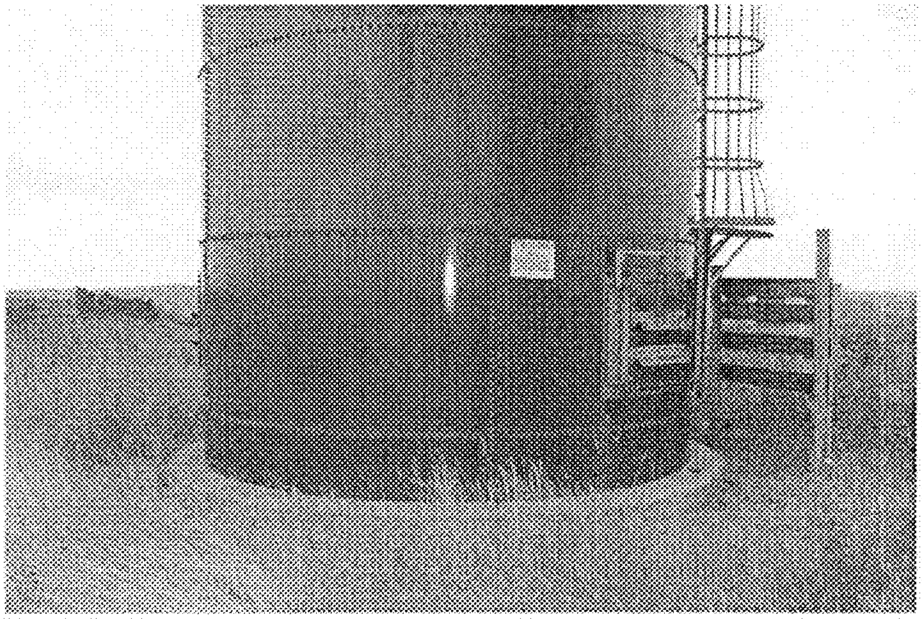

Fig. 3 Base of the Water Tower

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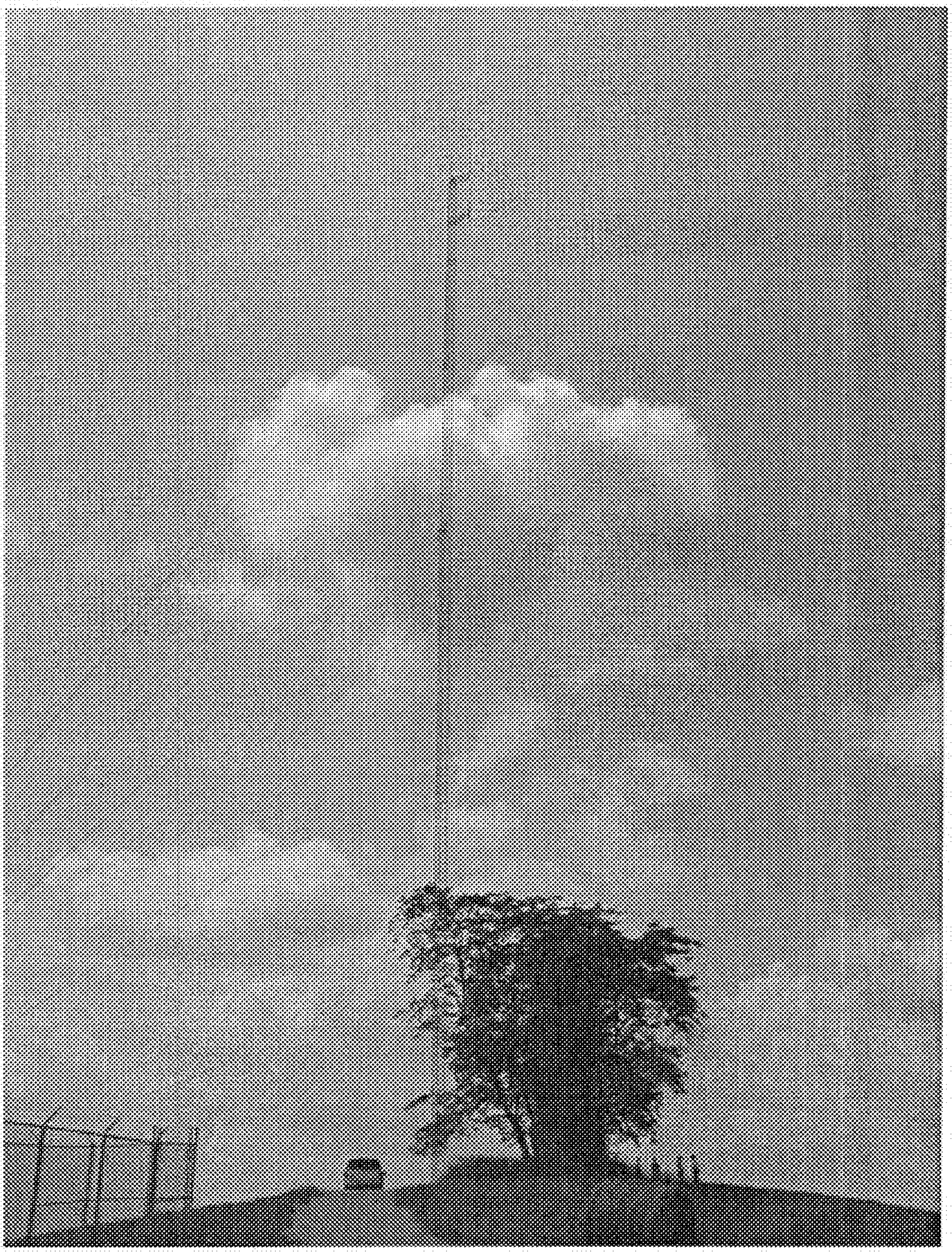

Fig. 3 Larger Communication Tower

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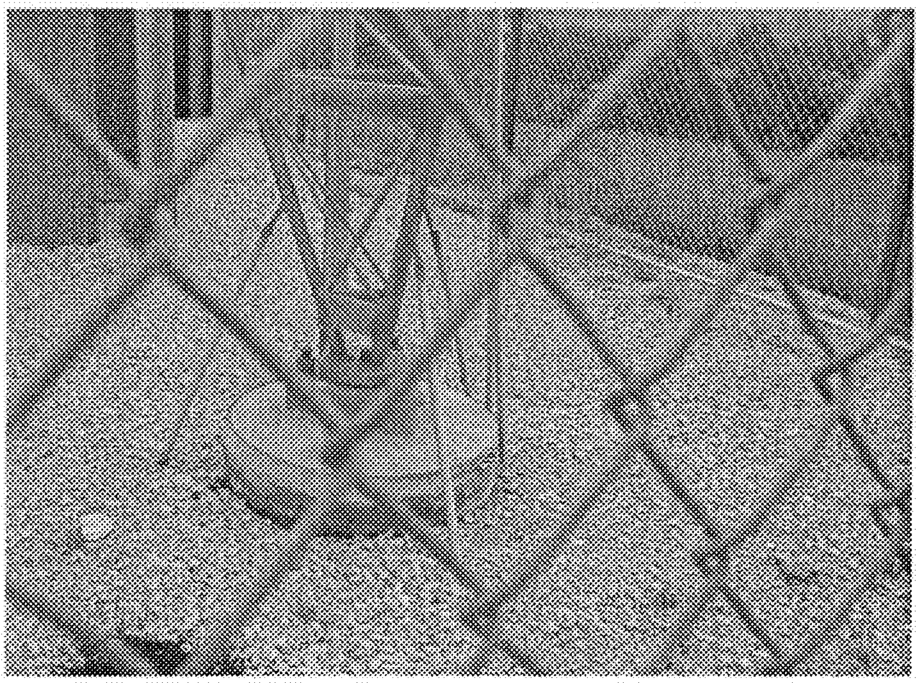

Fig. 5 Base of the Large Communication Tower

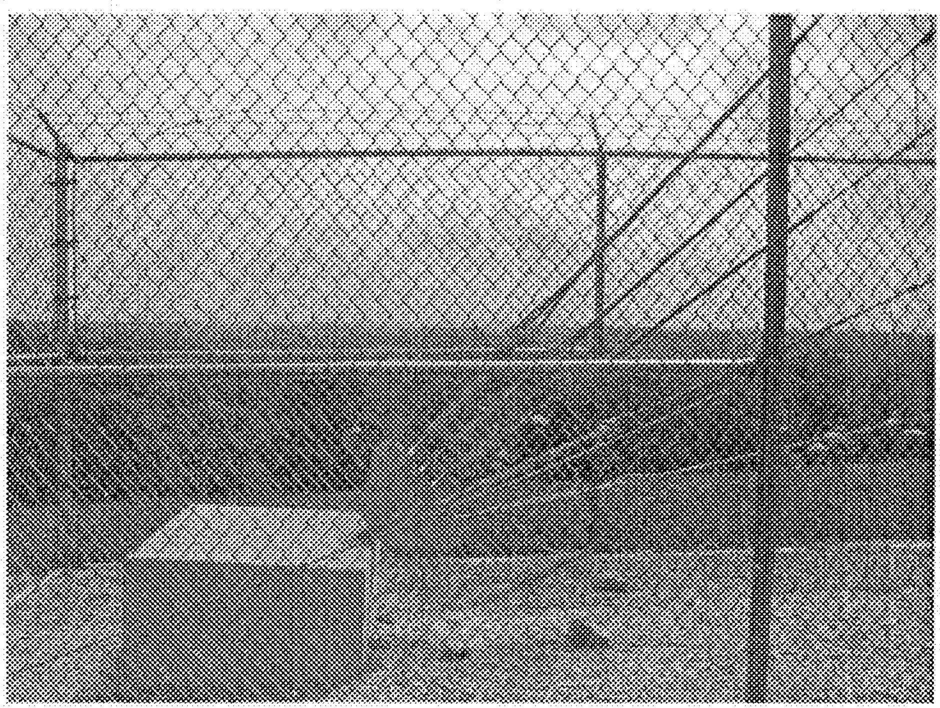

Fig. 6 One of the Three Anchors for the Large Communication Tower

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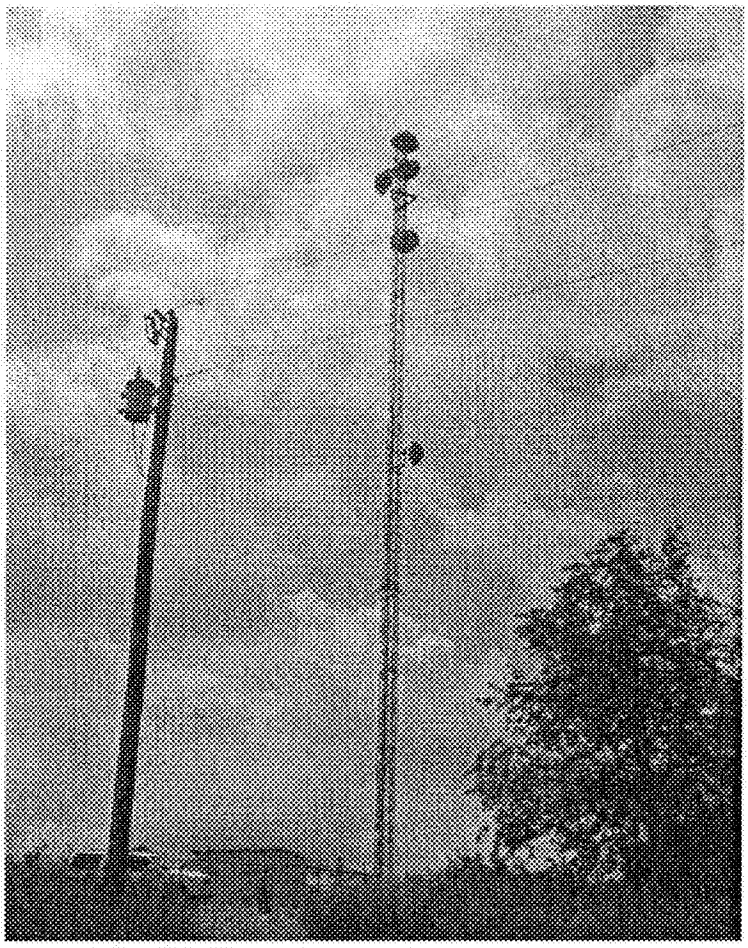

Fig. 7 Small Cell Phone Tower

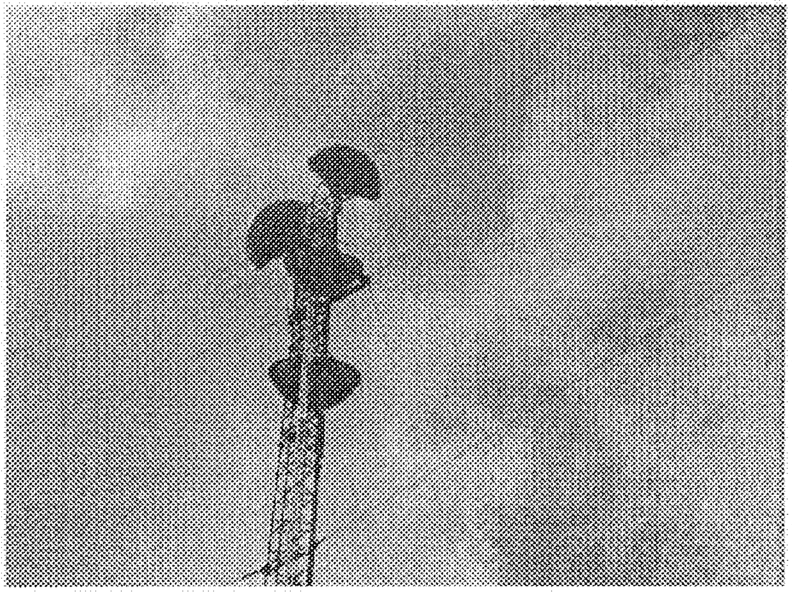

Fig. 8 Directional Control Guy Wires Tied at the Top Level

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One of the power transmission towers is shown in Fig. 9. All 14 power tower share the same structural design. The steel lattice tower has four legs bolted to their concrete bases. The side distance is about 28.5 ft. The tower is about 75 ft tall and the transmission lines are hung at two levels. The main load-bearing members of the tower are made of 5-inch angle steels while smaller bars or angle steels are used for the other members. The lowest restrictive horizontal bars are located about 20 ft above the ground surface.

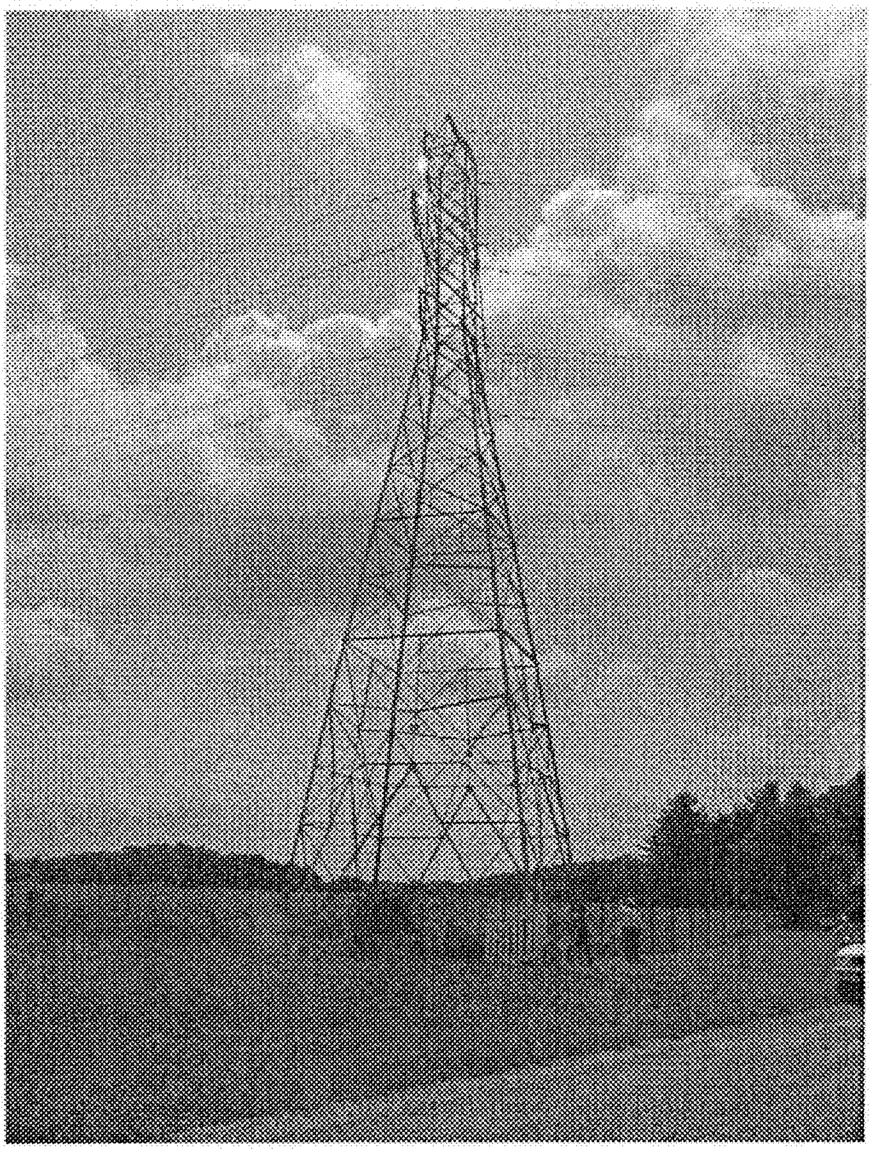

Fig. 9 Power Transmission Tower

ASSESSMENT AND MITIGATION OF THE SUBSIDENCE INFLUENCES

In this section, the potential subsidence influences on the water tower has been assessed and the mitigation measure for it has been recommended. In assessing the potential subsidence influences, the structural integrity, stability and functionality of the structures should be assessed. For the two communication towers, the methods for assessing and mitigating the influences are mentioned. Surveys to locate the anchors should be performed before the detailed analysis can be performed. Among the 14 transmission towers, eight of them could experience subsidence influences. The subsidence influences could be dependent on many factors and should be assessed one by one.

Influences on and Mitigation Measures for Water Tower

In order to assess the potential subsidence influences to the water tower, the final and dynamic surface movements at the location of the tower have been predicted. The subsidence prediction program CISPM version 2.01 is used. The development of the prediction package is based on the influence function method that is widely adopted in the major mining countries including US coal mining industry and a large amount of collected subsidence data. Most of subsidence cases are collected over longwall panels mining in the Pittsburgh coal seam. This subsidence prediction program package has been successfully applied in various subsidence projects and proven accurate.

The overburden depth at the location is about 745 ft and the center of the tower is located 325 ft inside the panel edge according to the new panel layout. A mining height of 6.0 ft is used in the prediction. The predicted final subsidence profile across a longwall panel with the minimum (460 ft) and maximum (745 ft) overburden depths are plotted in Fig. 10. The location of the water tower, as well as the two guyed telecommunication towers, is also shown in the figure. It shows that the tower is located near the flat bottom portion of the final subsidence basin to be formed over the longwall panel and the predicted final subsidence at the center of the tower is about 3.43 ft. Since the water tower is located on the top of a high hill with its elevation much higher than its customers in the adjacent area. The reduction on water head due to mining subsidence (only about 7% of the tower height) will be too insignificant to reduce its ability for serving the customers. The predicted final surface slope, strain and curvature are 0.31%, -5.2×10^{-3} ft/ft (compression) and -6.4×10^{-5} 1/ft (concave). Due to its small foot size, the water tower is very unlikely to be affected by these final deformations.

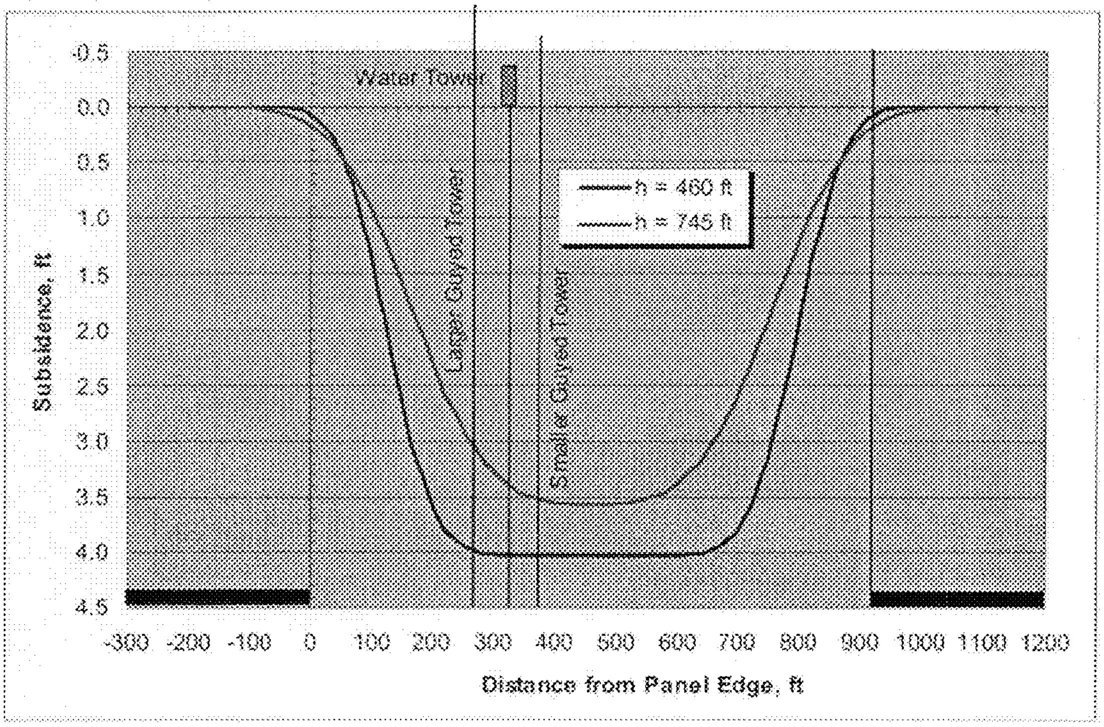

Fig. 10 Predicted Final Subsidence Along a Transverse Cross-section

Before the water tower finally settles down, it will experience a dynamic subsidence process. Figure 11 shows the predicted dynamic subsidence development curves at the location of the tower. Face advance rates in a large range of 20, 40, 60 and 80 ft/day have been used in the dynamic subsidence predictions. It shows the faster the face advances, the longer and gentler is the subsidence development curve. The tower is to experience the dynamic subsidence when the longwall face is about 50 ft inby and 700 ft outby the tower with the most active subsidence precess occurring when the longwall face is between 270 and 330 ft past the tower. Due to its small base and large height, the structural stability under the influence of dynamic subsidence process might be a concern. To assess the stability, the predicted dynamic slope development curves are shown in Fig. 12. The maximum dynamic slopes are 1.0%, 0.89%, 0.79% and 0.72% for the four ad-

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vance rates used. Such small dynamic slopes are even barely noticeable without pri. These maximum slopes would occur when the longwall face has passed the center of the tower a distance between 250 and 290 ft. Even when the water tank is operated at full level as the worst case, the center of the gravity of the water tower is located about 25 ft above the ground surface. Using the predicted maximum dynamic slope of 1.0%, the center of gravity of the tilted tower will only move a horizontal distance of 0.25 ft (3 inches) away from its original base center. Compared to the 7-ft radius of the tower base, the relocation of the center of gravity of the tower is very insignificant (3.6%). Therefore, the stability of the water tower will not be affected by the dynamic subsidence process at all.

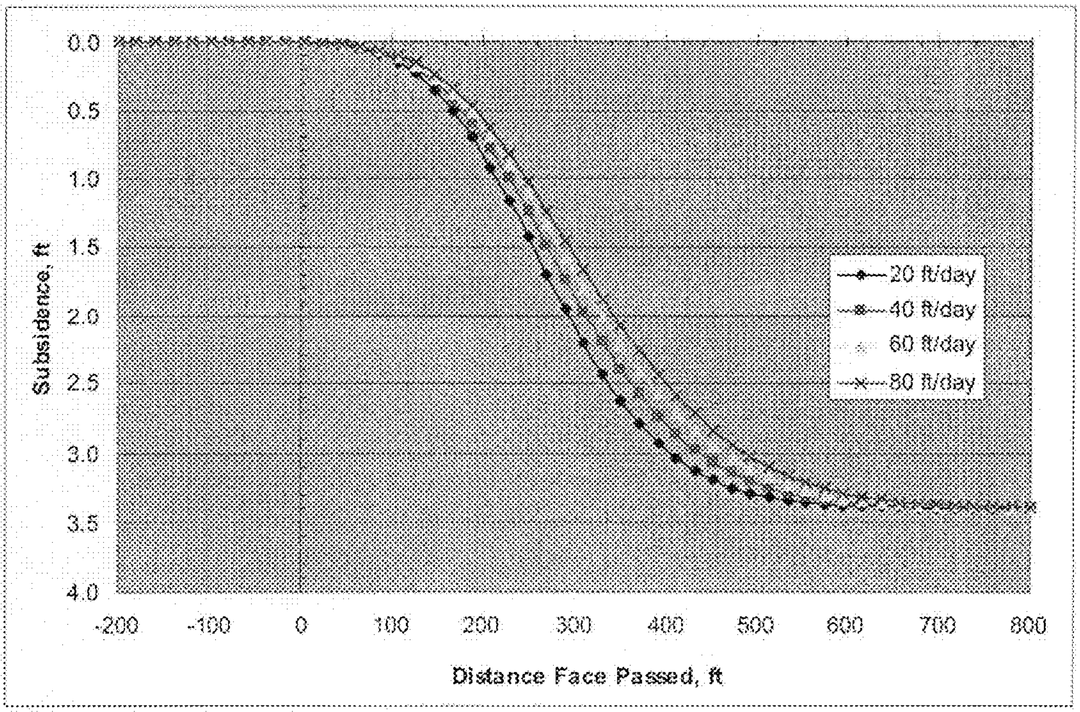

Fig. 11 Predicted Dynamic Subsidence Development Curves at the Water Tower with Various Face Advance Rates

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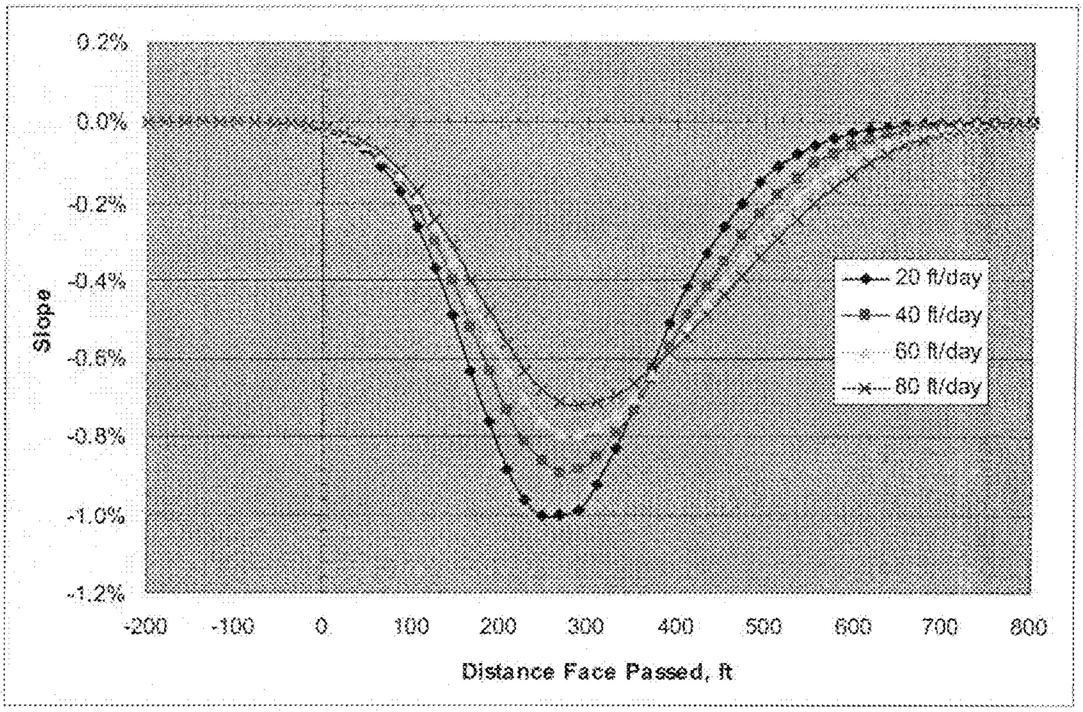

Fig. 12 Predicted Dynamic Slope Development Curves at the Water Tower

The predicted maximum dynamic tensile strains (not shown) for the ranges of face advance rates range from $3.46x10^{-3}$ to $5.51x10^{-3}$ ft/ft occurring at 165 ft behind the longwall face. The maximum dynamic tensile strain might be able to create some hairline cracks on the concrete base of the water tower. The maximum dynamic convex curvatures will be in the range from $4.19x10^{-5}$ to $6.67x10^{-5}$ 1/ft, too small to cause any problems to the water tower structures.

In order to prevent the concrete base of the water tower from being cracked by the dynamic tensile strain, it is recommended to wrap the concrete base with two steel tension cables. New 3/4 –inch steel wire cables should be used. The cables should be placed about 4-inches below the top surface of the concrete base and each cable should be tensioned to 4-tons (8,000 lbs). The cables should be installed when the longwall face is still 200 ft to the tower and can be released after the face has passed the tower a distance of 1,000 ft.

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Influences on and Mitigation Measures for the Telecommunication Towers

The locations of the two telecommunication towers with respect to the edges of the longwall panel are also plotted along with the predicted final subsidence profiles in Fig. 10. The smaller tower is located in the central and flat bottom portion of the subsidence basin with the final subsidence at its base being about 3.6 ft. The larger tower is located in the concave portion of the final subsidence basin and the final subsidence at its base is about 3.0 ft.

The assessment of subsidence influences on the guyed towers is much more complicated than that for the water tower. The authors have developed the assessment techniques and successfully applied them to one guyed tower that was similar to the two towers in this study and used for signal relay of cellular phone services. Based on the assessment, simple and inexpensive mitigation measures were recommended and mitigated. That tower was successfully protected and its services was never been affected despite of severe winter weather while mining was conducted under the tower. The publication (Luo et al, 2003) detailing the assessment techniques and mitigation measures is attached as an appendix. In assessing the influences, the following design and operating parameters of the towers are required:

- Coordinates and elevations of the tower base and ground anchors
- Elevations of the guy wire ties on the towers
- Sizes of guy wires
- Ranges of the tensions in the guy wires

We request these necessary design and operating parameters be provided before the detailed analyses on the potential subsidence influences on the guyed towers are performed. The predicted final and dynamic movements at the base and the anchors will be used in addition to other input information in assessing the subsidence influences on the guyed towers.

However, it is anticipated based on our past experience that the tensions in the guy wires could increase in the first half of the dynamic subsidence process and decrease in the second half of the process. If the guy wire tensions increase too much, they place a significant additional load on the lower members of the tower structure and potentially leads to problems to the tower base, the guy wires and the anchors. If the guy wire tension decreases too much, it could cause slacking condition to the guy wires which reduces lateral restraints to the main tower structure. The significant differential ground movements in both vertical and horizontal directions at the tower base and ground anchors will also cause vertical and horizontal rotations that could lead functionality problems to the towers.

However, as mentioned previously, we have developed and successfully applied some mitigation measures for such guyed towers. The mitigation measures could include: (1) periodical monitoring the tensions in the guy wires (i.e., 2 to 3 times a day during the active dynamic subsidence period) and adjusting the tensions in the guy wires if needed, and (2) monitoring the plumb of the main tower structures from two orthogonal directions (i.e., parallel and perpendicular to the mining direction) and adjust the guy wires as needed. These mitigation measures are relatively simple and inexpensive to implement.

Influences on and Mitigation Measures for the Power Transmission Towers

The 14 power transmission towers are located over two longwall panels according to the latest mine layout. Among them, three are located beyond the panel setup entries or recovery lines expecting no or very minor subsidence influences. Eight towers are located over or near the chain pillar system between two adjacent longwall panels. These towers are to experience a small amount of final subsidence but some of them may be subject to high final tensile strains. The remaining three power towers are located in the "central" portion of one longwall panel and expecting to experience strong dynamic subsidence process. Therefore, the power transmission towers located over the chain pillars system and within the panel edges may be affected by the proposal longwall mining operations. The severity of the potential subsidence influences to each of the tower could be different depends on their relative locations to the longwall panels, surface topography, the design and construction of the towers, etc. At the time of this writing, the design information of the power towers have not been provided for us to performed detailed analyses.

However, it should be noted that the authors have previously performed assessments on the subsidence effects and monitored the stress on a number of power transmis-

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sion towers similar to the ones in this permit area. That study found that the longwall subsidence process would have very little effects on the stability even when the lateral load by the strongest wind was applied on the subsided tower. That study also considered the additional tension or sagging conditions when two adjacent towers are subject to differential lateral movements and slopes during and after the subsidence process. It was found that such additional tension was insignificant to affect the power transmission lines. However, the differential movements, especially differential horizontal displacements, among the legs of each tower could cause bending and twisting to the steel members at the lower level.

In another study, the authors studied a very important and large 4-leg telecommunication tower located on the top of a very steep mountain peak (Luo and Peng, 1997). The tower was responsible for sending and receiving signals to telecommunication satellite for a national telephone company. It experienced two subsidence processes when two adjacent longwall panels were mined. The analyses on the stability, functionality and structural integrity were performed. It was found that the differential movements at the legs could cause problems to the lower parts of the tower. In order to reduce the severity of the anticipated subsidence influences, mitigation measures, including a compensation trench and bracing methods, were recommended and implemented for this tower. The mitigation was very successful. No damages were found on the tower structure despite that ground cracks were observed nearby. The services were never been interrupted. Based on the experiences with 4-leg towers, we believe that the same or similar mitigation measures can be applied in protecting these power transmission towers. In order to perform detailed analyses of the structures, design information from the power company is needed.

CONCLUSIONS

A preliminary study has been performed for three types of tower structures located in an area where the mining permit is in application process. It is concluded that among the three types of the structures:

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1. The stability and functionality of the water tower would not be affected by the dynamic subsidence process according to the new mine layout. The dynamic strain could cause some minor cracks on the concrete base of the tower but the anticipated problem can be controlled using tension cable method.
2. The potential subsidence influences on the two guyed telecommunication towers can be assessed using the techniques developed by the authors. Based on our previous experience, relatively simple and inexpensive mitigation measures can be applied to protect these two structures.
3. The subsidence influences on 4-leg steel towers for electrical power transmission can be assessed and mitigated using proven techniques.

REFERENCES

Luo, Y. and S.S. Peng, 1997, "Subsidence Prediction, Influence Assessment and Damage Control," *Proc. 16th Int'l Conference on Ground Control in Mining*, Ed. S.S. Peng, West Virginia University, WV, pp. 50-57.

Luo, Y., S.S. Peng and B. Miller, 2003, "Influences of Longwall Subsidence on a Guyed Steel Tower – A Case Study," *Proc. 22nd Int'l Conference on Ground Control in Mining*, Ed. S.S. Peng, C. Mark and A.W. Khair, pp. 360-366.

APPENDICES

Two publications by the authors
on assessing and mitigating subsidence influences
on tower structures.

22nd International Conference on Ground Control in Mining

Influences of Longwall Subsidence on a Guyed Steel Tower – A Case Study

Yi Luo, *P.E., Research Associate Professor*
Syd S. Peng, *C.T. Holland Professor and Department Chairman*
Department of Mining Engineering
West Virginia University
Morgantown, WV, USA

Brad Miller, *Division Land Representative – Coal East*
RAG Emerlad Resources, LP
Waynesburg, PA, USA

ABSTRACT

The potential influences of mining subsidence on structural stability, integrity and functionality of guyed tower structures have not been systematically studied before. This paper presents a case study where a guyed steel tower of a telecommunication company was mined under by a longwall operation. Prior to mining, every aspect of the subsidence influences to this structure was studied. The pre-mining assessment indicated that the structure could experience vibration problem in the second half of the dynamic subsidence process. Based on the study, a simple mitigation measure was recommended and implemented and the structure was successfully protected.

INTRODUCTION

Guyed tower structures have been frequently employed to elevate objects (e.g., radio or TV transmitters, wind turbines, etc.) high above ground surface because of their low construction cost and great stability. A guyed steel tower is consisted of a tall and slim steel lattice structure restrained laterally by a number of steel guy wires from different directions.

Mining in a longwall panel with a fairly large overburden was conducted under a guyed steel tower used for wireless phone service. Assessment of the influences of the subsidence process on this structure has been performed using the methods developed in this study prior to the longwall mining operation. The assessment concluded that the stability, integrity and functionality of this tower structure would not be affected by the subsidence process. However, the lateral restraint to the steel tower by the guy wires would be reduced, possibly causing vibration of the structure under gusty wind conditions, in the second half of the dynamic subsidence process. The only mitigation measure for this tower was to monitor and to maintain proper tensions on the guy wires. The structure was successfully protected and its services had never been affected.

This paper presents the methods for assessing the subsidence influences on the guyed tower at various stages of the subsidence process.

LONGWALL PANEL AND TOWER STRUCTURE

The portion of the longwall panel over which the transmission tower is located is shown in Fig. 1. The longwall panel was 874 ft wide (rib-to-rib) and the mining height in the Pittsburgh coal seam is between 6.5 and 7.0 ft. The base of the tower is located near the central portion of the longwall panel. The tower sits in a flat area on the top of a steep hill. The overburden depth at the tower base is about 1,017 ft.

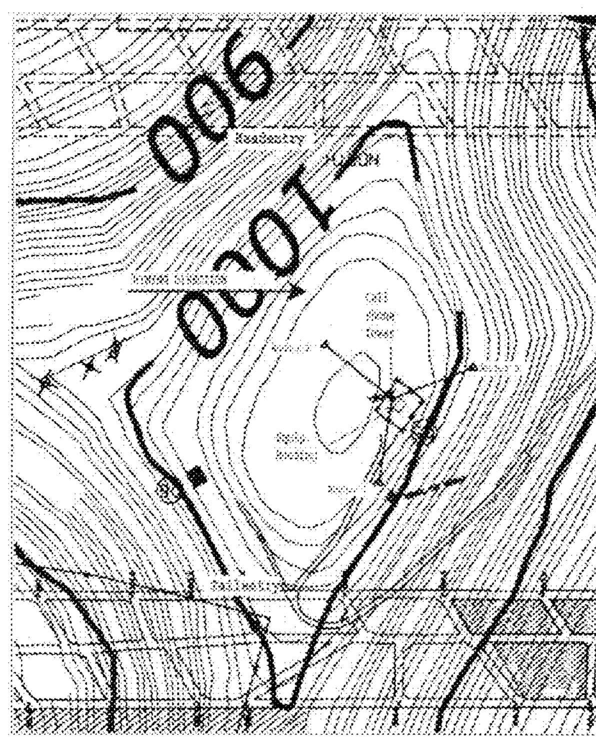

Fig. 1 Overview of the Site

The tower (Fig. 2), belonging to one of largest wireless phone companies in the nation, serves as a relay station to transmit cellular phone signals between two similar towers located more than 20 miles away in the tri-city area in the northern West Virginia and southwestern Pennsylvania. The steel lattice tower is about 180 ft tall and laterally restrained by 12 steel guy wires. These guy wires are installed in three vertical planes that are separated from each other by about a 120° horizontal angle. Along each plane, the lower ends of the four wires are tied to a concrete anchor block (Fig. 3) and the upper ends are tied to the tower at three different levels. The turnbuckle on each guy wire makes it possible to make necessary adjustment for regular maintenance. The anchors were located about 160 ft away from the tower base. The concrete anchor blocks, 2' (H) x 3' (W) x 7'-6" (L), were buried about 6 ft below the ground surface.

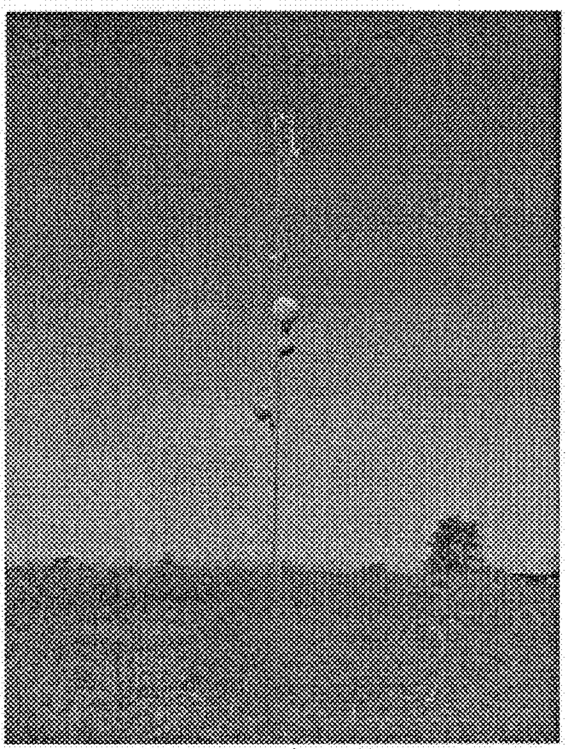

Fig. 2 Transmission Tower

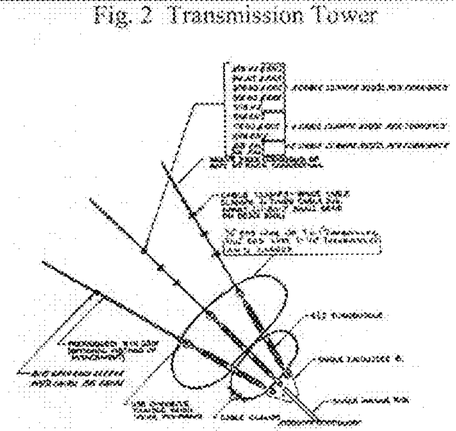

Fig. 3 Method to Tie the Guy Wires to the Anchor Block

Table 1 shows the pre-mining coordinates and elevations of the points of interest on the tower structure (i.e., base, anchors and ties). A local coordinate system is used for the structure. The datum of the elevation of the local coordinate system is set at the base of the tower ($z = 0$ ft at the base). It should be noted that the anchors are not on the same elevation as the tower base. The x-direction of the coordinate system follows the mining direction with $x = 0$ at the tower base. The y-axis points from the panel tailentry to the headentry with $y = 0$ at the panel tailentry.

Table 1 Local Coordinates of the Tower Base and Anchors

Point of Interest	x	y	z*
Base (0)	0	369	0
Anchor 1	149	427	-12
Anchor 2	-123	469	-6
Anchor 3	-23	215	-1
Tie 1	0	369	60
Tie 2	0	369	123
Tie 3	0	369	173

* elevations are expressed in relation to tower base

The tower super-structure is tied to its foundation with one steel bolt ($\phi = 15/16"$). The reinforced concrete foundation is constructed in two sections. The lower section is a square one with side length being 4'-6" and the thickness being 1'-6". The upper section is cylindrical with its diameter and height being 2 and 4 ft, respectively. The foundation is buried with only the top 6 inches being exposed above the ground surface.

In each of the three guy wire planes, one guy wire ($\phi = 3/8"$) is used at the lower level located about 60 ft above the tower base (referred as Tie 1). Two guy wires ($\phi = 7/16"$) are tied to the tower at the middle level (123 ft above the tower base) to resist the possible rotation of the tower structure (Tie 2). The top of the tower is tied with one guy wire ($\phi = 7/16"$) at the elevation of 173 ft above the tower base (Tie 3). At lower and top tie levels, breast type of ties are used to provide lateral restrain to the tower only while the middle tie is a torque type to provide both lateral and rotational restrains to the tower as shown in Fig. 4. The guy wires have been pre-tensioned with the tensions ranging from 1,250 lbs at the lower level to 1,975 lbs at the top level.

SUBSIDENCE PREDICTION

In order to assess the potential subsidence influence on the tower structures, dynamic subsidence prediction is performed at four surface points of interest, the tower base and the three anchors, using the subsidence prediction program CISPM version 2.01 (Peng and Luo, 1992). Mining height of 7.0 ft and an advance rate of 80 ft/day were used in the predictions.

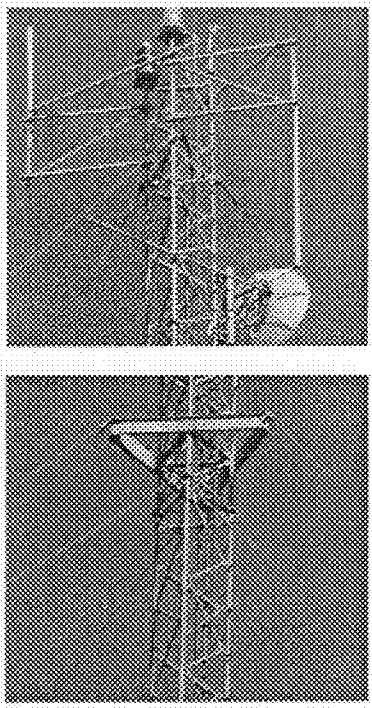

Fig. 4 Breast Type (Top) and Torque Type (Bottom) Ties

The predictions was performed at different time stages ranging from when the longwall face was from 300 ft inby to 1,700 ft outby the tower base. These time stages are chosen to cover the entire active dynamic subsidence process. The prediction for the last time stage (i.e., the face has passed the tower base for a distance of 1,700 ft) should be considered as the final subsidence. The predicted surface subsidence (S) and the two components of horizontal displacement (U_x and U_y along the x and y directions, respectively) at these specified time stages are plotted in Figs. 5, 6 and 7, respectively.

Figure 5 shows the predicted subsidence development curves at the tower base and anchors. Insignificant amount of subsidence would be experienced by the tower structures when the longwall face was directly under the tower base. The subsidence process would be most active when the face was between 300 and 400 ft passed the tower base. The ground begin to regain stability after the face has passed the tower base a distance of 1,000 ft. The final prediction shows that anchor 1 will subside the most (3.06 ft) while anchor 3 the least (1.62 ft). There is no significant differential subsidence among the base, anchors 1 and 2 after the subsidence process is over.

The predicted development curves of horizontal displacements along the mining direction are plotted in Fig. 6. The negative values shown in the figure indicate that the movements were against the mining direction. The maximum movements along the mining direction ranged from 0.43 to 0.54 ft when the longwall face was between 300 and 700 ft passed the tower base.

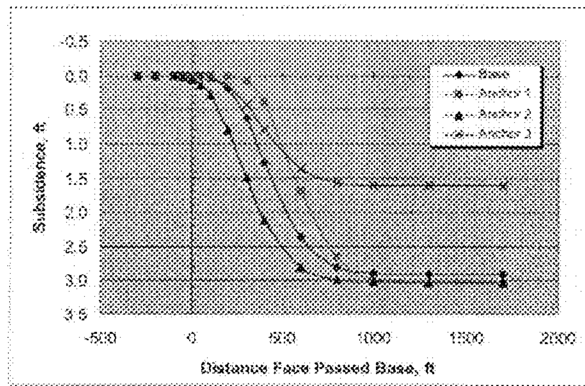

Fig. 5 Predicted Dynamic Subsidence

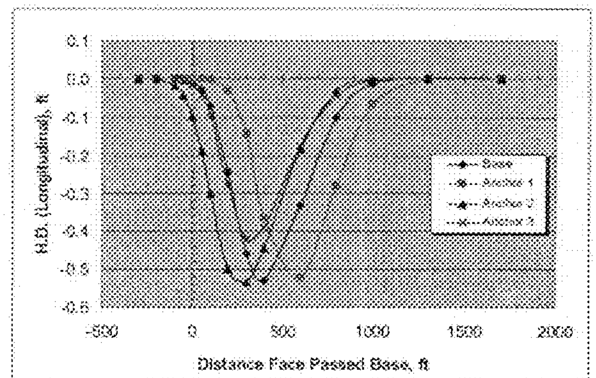

Fig. 6 Predicted Dynamic Horizontal Displacement Along Mining Direction

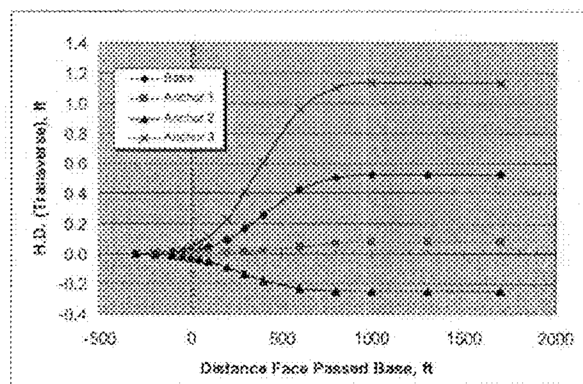

Fig. 7 Predicted Dynamic Horizontal Displacement Along Panel Transverse Direction

The predicted development curves of horizontal displacements along the panel transverse direction are plotted in Fig. 7. A positive value indicates movement from the panel tailentry to headentry. It shows that the base and anchors 1 and 3 would move toward the panel headentry side while anchor 2 would move toward the panel tailentry side. Among these four points, anchor 3 will have the largest movement (1.15 ft) while anchor 1 will have the least movement (0.07 ft) when the subsidence process is over.

ASSESSMENT OF SUBSIDENCE INFLUENCES

Based on the predicted dynamic surface movements at the tower base and three anchors as well as the structural characteristics of the tower, the movements and deformations of the tower structure can be determined. Subsequently, the following three aspects of potential influences that the ground subsidence process could cause to the tower structures can be assessed.

- *Structural stability*: Since the tower structure is tall and sits on the hill top, its stability during and after the subsidence process was a concern.
- *Structural integrity*: The subsidence process could induce some additional forces on various parts of the tower structures. If strong enough, these forces could cause structural damages to some of the structural parts.
- *Functionality*: If the tilting and rotation of the transmission tower induced by the subsidence process exceed certain critical values, they could cause blockage and alignment problems to the paths of the signal transmission resulting in disruption or degradation of the cellular phone services.

Assessment of Structural Stability

Stability analysis is normally required for tall structure with small bases such as transmission tower to assess the potential for the structure to be toppled by external lateral forces. Because of their designs, the guyed towers are a type of very stable tower structures that can sustain high winds, earthquakes and extreme weather. The stability of the guyed tower could only be jeopardized when some of the guy wires, especially those tied to the upper levels of the towers, break under some extreme forces. The determination of the subsidence-induced forces in the guy wires to be induced for this case is presented in the next section. That analysis indicated that the subsidence-induced tensions in the guy wires were insignificant compared to pre-tensions in these wires and to their ultimate breaking loads of the steel cables. Therefore, the ground subsidence process associated with the longwall mining operation will not affect the stability of this particular transmission tower.

Assessment of Structural Integrity

As the ground subsides, the relative spatial locations of the tower base and the anchors, the ground-contacting points of the guyed tower structure, will change. Such changes in elevations and coordinates of these ground-contacting points could induce additional tensions or slacking condition in the guy wires and additional loads in the tower structure.

Determination of Tower Equilibrium State

In determining the subsidence-induced tensions and loads, the predicted dynamic surface movements at the tower base and the anchors at a time stage are imposed on their respective original coordinates and elevations listed in Table 1. The most important task is to determine the coordinates of the ties on the tower when a new equilibrium is developed in the tower structure for that time stage. Since the guy wires tied to each of the three ties on the tower are of the same size (3/8" for wires connected to tie 1, and 7/16" to ties 2 and 3), the following conditions should be satisfied when a new equilibrium at each tie position is reached.

$$\begin{cases} \sum_{i=1}^{3} \varepsilon_i \cos\beta_i \cos\alpha_i = 0 \\ \sum_{i=1}^{3} \varepsilon_i \sin\beta_i \cos\alpha_i = 0 \end{cases} \qquad (1)$$

In Equation 1, ε_i is the subsidence-induced strain developed in the guy wire connected between anchor i and the tie of interest. The horizontal angle between this guy wire and the mining direction is β_i while the slope angle is expressed as α_i. The subsidence-induced strain in this guy wire is determined as:

$$\varepsilon_i = \frac{\sqrt{(x_i - x_o)^2 + (y_i - y_o)^2 + (z_i - z_o)^2} - L_o}{L_o} \qquad (2)$$

In equation 2, x_i, y_i, and z_i are the coordinates and elevation of ground anchor i at a given time stage. The coordinates and elevation at a given tie on the tower are x_o, y_o, and z_o. The original length of the guy wire is L_o. In setting up equations 1 and 2, the following two reasonable assumptions are made:

- The vertical deformation of the tower structure is insignificant. Therefore, the new elevation at a tie position z_o is equal to the elevation of the subsiding tower base plus the original height of this tie.
- The ability for the tower structure itself at the tie levels to resist lateral displacement is insignificant.

By solving the two simultaneous nonlinear equations (Eq. 1), the coordinates, x_o and y_o, of each of the three ties can be determined when the new equilibrium of the tower structures is reached at a given time stage. A computer program was developed for solving the simultaneous nonlinear equations involved in this task. Using the program repeatedly, the coordinates for the three ties and the horizontal displacements (x-component, y-component and principal, Δx, Δy and ΔU) of these three ties relative to the tower base were determined and the results are shown in Figs. 6, 7 and 8, respectively. It is apparent that the upper part of the tower would displace with respect to its base more than the lower part.

Changes in Guy Wire Tensions

Using these determined coordinates of the ties and the anchors, the subsidence-induced strains in the guy wires on the tower base can be determined. In converting the subsidence-induced strain (Eq. 2) to the subsidence-induced tension, the stiffness (S) of each of the two types of the steel wire ropes should be determined based on the average value of 6-strand and 8-strand steel wire ropes as:

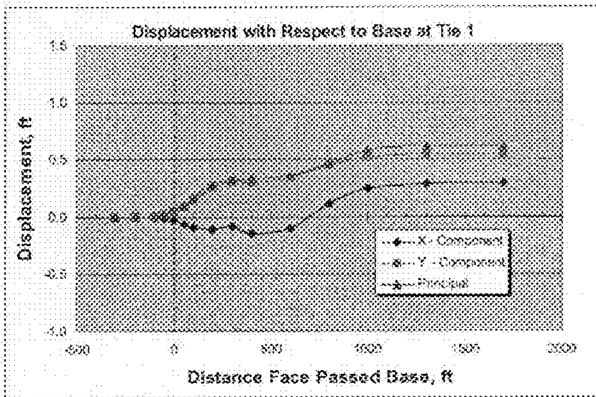

Fig. 6 Horizontal Displacements of Tie 1

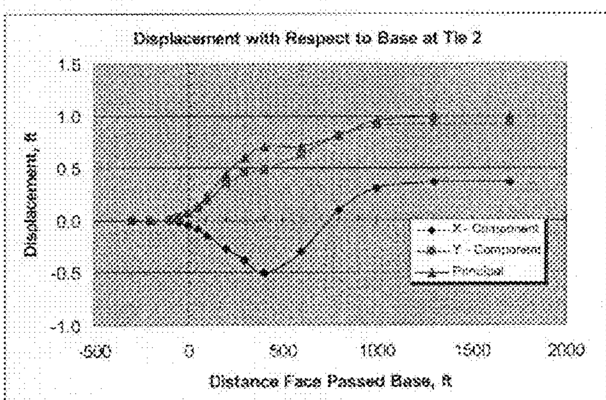

Fig. 7 Horizontal Displacements of Tie 2

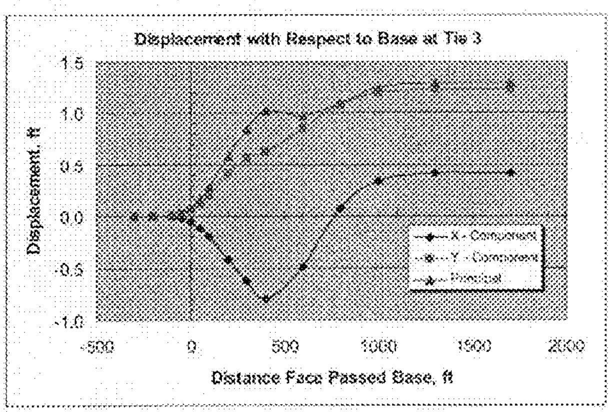

Fig. 8 Horizontal Displacements of Tie 3

$$S = 10x10^6 A \qquad \text{lbs} \qquad (3)$$

In Eq. 3, A is the cross-sectional area of the wire rope. The stiffness values used in the conversion are 1,104,466 and 1,503,301 lbs ft/ft for the 3/8" and 7/16" guy wires, respectively. The average tensions in the guy wires induced by the ground subsidence process associated with the longwall operation are plotted in Fig. 9. A positive value indicates that an additional tension has been induced in the guy wire by the subsidence process while a negative value shows that the existing tension in the guy wire observed before mining will be reduced. A negative force is only meaningful when its magnitude is smaller than the pre-mining tension in the guy wire. Figure 9 shows that tensions would develop in the guy wires when the longwall face is between 50 ft inby and 300 ft outby the tower base. The maximum subsidence-induced tension was about 780 lbs for guy wires tied to the level 3 of the tower when the longwall face is about 200 ft passed the tower base. Such additional tensions are smaller than the pre-mining tensions ranging from 1,250 to 1,975 lbs and are insignificant compared to the ultimate breaking strengths of the guy wires (10,600 lbs for 3/8" wire rope and 14,400 lbs for 7/16" wire rope). Therefore, the subsidence-induced tensions were incapable of causing breakage of the guy wires.

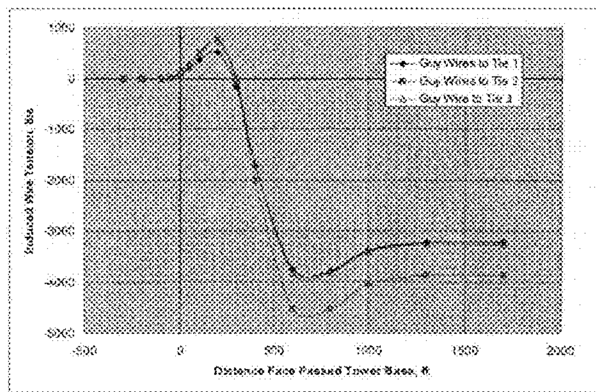

Fig. 9 Subsidence-Induced Tensions in the Guy Wires

However, after the longwall face has passed the tower base a distance 350 ft, the tensions in the guy wires become nonexistent (The magnitudes of the negative values are larger than the pre-mining wire tensions). Under such condition, the guy wires would slack and the tower would be no longer effectively restrained laterally by the guy wires within certain small range. The lack of effective lateral restraint makes it possible for the tower, especially its upper sections, to vibrate under strong gushing winds.

Additional Load to the Tower

The subsidence-induced tensions in the guy wires also induce additional loads to the tower structure, especially in the section near the tower base. The additional load in the lower section at a given time stage is the summation of the vertical components of the tensions in all of the guy wires. The calculations show that additional loads can be induced in the first half of the dynamic subsidence process until the longwall face has passed the tower base a distance of 350 ft. The maximum subsidence-induced load on the tower base would be 4,947 lbs when the face was 200 ft past the base. Such additional load was also insignificant compared to the weight of the steel tower structure and the load from the pre-mining wire tensions (about 12,000 lbs). Therefore, the subsidence-induced load to the tower base would not cause any structural integrity problems to the tower.

Bending Curvature on the Tower

The differential lateral displacements between the base and the three ties would create a bending condition in the tow lattice structure. The calculation shows that the lower part of the tower was bent laterally more severely than the upper part. However, the maximum bending curvature, $5.5x10^{-5}$ 1/ft in the lower part when the longwall face was about 300 ft passed the tower base, was still insignificant for the tower steel lattice structure. Therefore, the bending developed on the tower structure would have no effect on its structural integrity.

Assessment of Structural Functionality

The assessment of subsidence influences on the functionality of the transmission tower is to assess whether the ground subsidence process is to disrupt or degrade the ability of the transmitters on the tower to relay phone signals to and from the transmission towers in the other two cities. Such ability could be potentially affected by: the blockage of the signal path, and (2) the incorrect alignment of the signal path. This section assesses the possibilities for such two potential problems to occur during and after the ground subsidence process.

Possibility of Signal Path Blockage

The cellular phone company was concerned with the vertical subsidence at the location of the tower base that would place the tower a few feet (2.9 ft as predicted and shown in Fig. 5) lower than its original elevation. It was thought that such lowering of tower elevation could make high obstacles (such as large trees) to intrude into the signal path between the transmission towers causing signal blockage.

However, it should be noted that the transmission tower was located on the top of one of the highest hills, if not the only highest hill, in a large area around and the transmitters were also located high above the ground on the tower. The ground subsidence process would not only lower the tower but also the surrounding surface area to certain extent. Therefore, the signal paths are impossible to be blocked by any local obstacles around this transmission tower.

Another fact was that the other two transmission towers were located about 23.5 miles (air distance) away from this transmission tower. The predicted 2.9 ft elevation lowering at this transmission tower would only change the signal path by a minor angle of 4.84 seconds. Such insignificant change in signal path would make it impossible for any obstacles located close to the other towers to intrude into the signal paths, either. Therefore, the possibility for the subsidence process to cause blockage of the signal paths was none.

Possibility of Misalignment of Signal Paths

During and after the subsidence process, some minor inclination and rotation will develop on the tower structure. Such inclination and rotation, if large enough, could affect the alignment of the signal paths between the transmitters. According to the cellular phone company, any inclination away from the vertical direction or rotation in the horizontal plane of the tower larger than one degree could affect the alignment of the signal paths.

Based on the determined coordinates and elevations of the tower base and the ties, the inclinations of the tower structures away from the vertical direction at each time stage were determined for each section and the entire height of the tower. The results include inclinations along x and y directions as well as the principal one. The principal inclination of the tower would increase as the dynamic subsidence process with the maximum being reached when the ground regains its stability. The maximum inclinations would be 0.59°, 0.36° and 0.35° for the lower, middle and top sections, respectively. The maximum inclination for the entire tower is about 0.43°.

The rotation of the tower structure is determined using the coordinates of the anchors and tie 2 because torque type tie at this level were designed to provide rotational restraint to the tower lattice structure. The maximum tower rotation, 0.56°, would occur when the dynamic subsidence process was over.

The analysis indicated that both the maximum inclination and the maximum rotation of the tower are smaller than their critical values. Therefore, the alignments of the signal paths would not be affected by the ground subsidence process associated with the longwall mining operation, either.

MITIGATION MEASURE AND RESULTS

Based on the analyses performed, it was concluded that the only possible problem is the vibration of the tower under strong gushing winds due to the lack of effective lateral restraint by the guy wires. Such condition would occur in the second half of the dynamic subsidence process starting at the time when the longwall face is 300 ft outby the tower base.

In order to prevent the condition for potential vibration from occurring, it was recommended that the tensions in the guy wires were to be monitored daily when the longwall face is between 0 and 1,000 ft past the tower base. Necessary adjustments should be made by loosening or tightening the turnbuckles (Fig. 3) on the guy wires near the anchor blocks to maintain the needed tension levels. During the time period when the face is between 300 and 750 ft passt the tower base, multiple adjustments should be made daily to compensate the anticipated large reduction of tensions in the guy wires. When making these adjustments, the plumbing of the lattice structure should be also checked to avoid over-adjustments.

Mining under the tower started in the early January, 2003. The recommended mitigation measure was implemented. The dynamic subsidence process in the area of the transmission tower was over by the end of that month. Despite severe winter weathers in the first two to three months of this year, the tower was successfully protected and no complaints about the phone services were made.

CONCLUSIONS

This paper presents a case study where a telecommunication transmission tower was subsided by a longwall operation. The potential subsidence influences on the structure were carefully assessed based on the predicted surface movements in the dynamic subsidence process and the structural information of the tower using a systematic approach.

The assessment indicated that structural stability, integrity and functionality of this tower would not be significantly affected by the subsidence event. However, a vibration condition could develop in the second half of the dynamic subsidence process because of the slack of the guy wires.

Based on the assessment, a simple mitigation measure, monitoring and tension adjustment was recommended and implemented. The project was successful as evidenced by the continued quality service carried by this transmission tower.

REFERENCE

Peng, S.S. and Y. Luo, 1992, "Comprehensive and Integrated Subsidence Prediction Model - CISPM (V2.0)," *Proc. 3rd Workshop on Surface Subsidence Due to Underground Mining*, Ed. S.S. Peng, West Virginia University, Morgantown, WV, pp. 22-31.

Subsidence Prediction Influence Assessment and Damage Control

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ABSTRACT

An extensive subsidence research program conducted by the authors has greatly improved the accuracy and the capabilities of subsidence prediction under complicated mining and surface conditions. The techniques developed for assessing and mitigating subsidence influences on various surface structures have been applied in numerous cases with a very good record of success.

INTRODUCTION

Total extraction of a coal seam using longwall mining or room-and-pillar mining with pillar extraction tends to disturb the overburden strata and causes immediate surface subsidence. Depending on various factors, such subsidence events may or may not have the potential to cause problems to surface structures. Surface subsidence research conducted by the authors has demonstrated that in order to effectively and efficiently minimize the subsidence influences on surface structures, the following techniques should be applied systematically:

- *Methods for accurately predicting surface subsidence under varying mining and surface conditions.* Success in dealing with the issues of subsidence depends primarily on the accurate prediction of the magnitude, distribution and timing of surface subsidence. By studying the subsidence basins produced by different mining plans, the possible subsidence effects on surface structures can be greatly reduced.
- *Techniques for assessing the subsidence influences on surface structures.* The probability and severity of subsidence influences on a structure of interest need to be assessed before it is undermined. Due to the large differences in types, design, material and construction of the structures as well as variations of movements and deformations to be experienced by the structures, the different assessment techniques are required.
- *Techniques for mitigating subsidence influences.* If the assessment indicates that the subsidence influences on a structure exceed the structure's tolerable level in terms of its integrity, stability and functionality, proper mitigation techniques should be designed and implemented to reduce the subsidence influences on the structure.

This paper describe the efforts and results of a subsidence research program conducted by the authors.

SUBSIDENCE PREDICTION

Accurate prediction of surface subsidence caused by underground mining is required for assessment of the subsidence influences and is the basis for the design of effective and efficient mitigation measures. In the past a great majority of subsidence research have been concentrated on the prediction of final subsidence over a single longwall panel with a relatively flat surface. The prediction models produced by those researches have limited value for practical applications because of varying and complicated mining, geological and topographical conditions. In order to improve the prediction accuracy, the authors have collected more than 200 longwall subsidence cases all over the US coal fields through an intensive subsidence monitoring program and from various other sources. These data were used to continuously refine and improve a PC-based program package, CISPM (Comprehensive and Integrated Subsidence Prediction Model) developed previously by the authors (Peng and Luo, 1992). This program package has a unique and rich set of capabilities for meeting nearly all of the subsidence prediction requirements in underground coal mining employing high or total extraction methods in the US. It is very user-friendly requiring neither particular skills in computer operations nor in-depth knowledge of subsidence theory. It has been proven fairly accurate according to the feedback from its domestic and international users and according to our own subsidence monitoring data. The following important findings from our subsidence research program have been incorporated into the current version of CISPM program package:

- *Dynamic subsidence process associated with longwall mining operations.* As underground mining progresses, a surface point will experience a fairly complicated dynamic subsidence process before it becomes stable again. During the dynamic subsidence process, the magnitudes, natures and directions of the subsidence movements and deformations at the surface point change with time and their influences to structures are also time dependent. Very often the dynamic subsidence process plays a more important role in assessing and mitigating subsidence influences than final subsidence. Mathematical models have been developed to predict the entire dynamic subsidence process associated with longwall mining operations (Luo and Peng, 1992).
- *Final subsidence basin over a single and multiple longwall panels.* Most of the subsidence prediction methods have been developed for mining of a single panel only. They are unsuitable for the prediction of subsidence over multiple panels such as the longwall panels separated by chain pillar systems as normally practiced in the US. A mathematical model has been developed to predict the final subsidence basin over multiple longwall panels (Luo and Peng, 1990, 1991). This model is based on the finding that the convergence of the chain pillar systems between the longwall panels could contribute a very significant amount of subsidence in the area over and near the chain pillars.
- *Final subsidence caused by high extraction room-and-pillar mining method.* If the recovery ratio in a room-and-pillar panel is 70% or higher by partially or fully extracting the pillars in a room-and-pillar panel, immediate surface subsidence (versus the unpredictable subsidence events over low extraction room-and-pillar mines often seen as the abandoned mine subsidence) will be induced. The existing methods which have been derived from subsidence data collected over longwall panels are not suitable for subsidence prediction over high extraction room-and-pillar mines. Based on the available subsidence data collected over room-and-pillar panels, a method has been developed for the prediction of the final subsidence basin over high extraction room-and-pillar panels (Luo and Peng, 1993).
- *Studies of subsidence parameters.* The two basic components of a subsidence prediction method are the chosen mathematical models and the parameters involved in the mathematical model. The subsidence parameters often play a very important role in the prediction accuracy. However, the reported subsidence parameters often vary in very large ranges which are of little values in practical applications. Such large variations are often resulted from the use of inconsistent definitions of the subsidence parameters and inadequate determination methods. A great effort has been made in collecting subsidence data in the US coal fields, standardizing the definitions of and determining the subsidence parameters (Peng et al., 1995). Based on this study, the ranges of a number of commonly used final subsidence parameters have been greatly narrowed.

In additional to prediction of surface subsidence, tools are provided and self improvement mechanism is built in CISPM. They include data processing for subsidence survey, determination of subsidence parameters based on mining and geological information and deduction of parameters from collected subsidence data

Numerous field observations have demonstrated that complicated surface topography and steep surface slope in hilly regions have a profound impact on the ground subsidence process, often resulting in very different characteristics of subsidence basin from that on a relatively flat surface. Effort has been made to study the surface topography effects on ground subsidence process. A method has been developed for the prediction of final subsidence basin in hilly regions (Luo and Peng, 1990). Figure 1 shows a comparison of the calculated final horizontal displacement profiles with and without considerations of the surface topography. The surface elevation is also plotted at the top for reference. A much better agreement with the measured horizontal displacement in the steepest portion of the subsidence monument line has achieved when surface natural slope was considered. It should be noted that horizontal displacement often plays a much more important role in causing damages to surface structures than subsidence (i.e., vertical settlement).

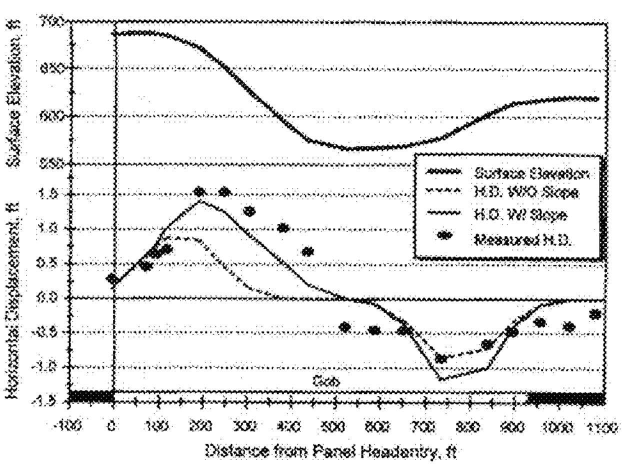

Fig. 1 Measured vs. calculated final horizontal displacement (H.D.) profiles along a cross-section over a longwall panel with relatively steep surface slope

TECHNIQUES FOR ASSESSMENT OF SUBSIDENCE INFLUENCES

Research emphasis has also been placed on monitoring the interaction between the subsiding surface and various surface structures. Based on the collected data, critical deformation values for various relatively simple structures have been

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established, techniques for assessing subsidence influences on those structures of large dimension and/or complexity have been developed.

A number of critical deformation values for typical residential structures (wood frame or brick super-structure on stone or concrete-block basement or foundation) in the northern Appalachian coal fields have been established. High surface tension and compression are generally responsible for cracks and buckling on the lower portion of the residential structures, respectively. High surface bending could causes problems to the super-structures such as sticky doors and windows, fissures on dry walls, peeling of old wall papers and paint. It is also found that a large tilting on floor could cause some inconveniences to the residents.

Ground cracks and bumps are caused by high surface tension and compression, respectively. Ground cracks as wide as 4 ft, though very rare, have been observed in certain locations over a few longwall panels. Generally ground cracks cause more problems (e.g., dewatering of surface streams or ponds) than the bumps. Criteria for initiating ground cracks on various ground surface have also been established.

For those structures of large dimensions and/or complicated design and construction, a more comprehensive and detailed assessment should be performed. However, due to the large variation of type, material, construction, dimension and functions of the structures, the techniques for assessing the subsidence influences on these types of structures vary considerably. Basic analysis should be performed to determine the nature and severity of the following three types of potential problems:

- *Structural integrity*: This is an indicator of mechanical failure of a structure of interest under the influence of subsidence. Ideally, the stress or strain field on the structures should be evaluated. The peak stress or strain are then compared to the permissible values of the structural material to determine the possibility of structural failure. For instance, a method has been proposed and successfully applied to assess the stress distribution on buried pipeline affected by subsidence (Peng and Luo, 1988). In cases where stress/strain fields are difficult or impossible to determine, the weakest components of the structure should be identified and empirical values are used to determine their integrity under the influence of surface subsidence.
- *Structural stability*: For those tall structures with small bases, the subsidence-induced slope could make them potentially unstable during or after subsidence process. Both the short and long term stability of the structure should be assessed. If the subsidence-induced slope could move the center of gravity of a structure out of its base, the structure is said to have lost its short-term stability. A structure loses its long-term stability if the strongest wind blowing in the direction of maximum slope caused by subsidence will be able to topple the structure.
- *Structural functionality*: The ability and level for the structures to perform their intended functions during and after subsidence may be affected by ground subsidence process. For example, subsidence could change the grade of a railroad well above its permissible grade. A conveyor belt could be rendered inoperable due to vertical and lateral alignment problems caused by the subsidence process.

The authors have applied the established criteria and the developed assessment techniques in various projects in assessing subsidence influences on various surface structures. Some examples of applying these assessment techniques are shown in Table 1.

TECHNIQUES FOR SUBSIDENCE MITIGATION

If the assessment indicates that a structure will be adversely affected, effective and efficient mitigation measures should be designed and implemented. The following three approaches can be used to design the mitigation measures: (1) reducing surface movements and deformations in the area of concern to an acceptable level by modifying the mining plan (e.g., leaving a support area under the structure), (2) reducing transmission of movements and deformations from ground to the structure of interest (e.g., trenching and plan-fitting), and (3) reinforcing the structure so that it can tolerate higher

Fig. 2 This telecommunication transmission tower, about 200 ft tall, was located on a steep slope of a mountain peak. It was undermined by a longwall panel. In order to protect this tower, trench was dug around one of its legs and reinforcement beams were installed at the base. Despite of ground cracks observed nearby, there was no damage on thestructure and its service was kept open all time.

Table 1 Some Examples of Subsidence Influence Assessments and Results

Structure or Feature	Descriptions	Major Concerns	Conclusions and Recommendations	Results
Residential Structures	More than 50 houses over or near longwall panels	Structural integrity and functionality	Varying damage potentials and mitigation measures recommended for about 30 structures	Accurate assessments and successful protection
Oil pipeline	Buried oil pipeline over 7 longwall panels	Structural integrity	Damage potential high. Mitigation measures recommended.	Feedback not available
Concrete water pipeline	Main transmission pipeline over 3 longwall panels	Structural integrity and functionality	Damage potential high. Mitigation measures and alternatives recommended	Alternative plan adopted
Cast iron water pipeline	Two pipelines over 2 longwall panels	Structural integrity and functionality	Damage potential moderate. Mitigations recommended.	Not yet undermined
Steel water pipeline	Main water supply line over 4 longwall panels	Structural integrity and functionality	Damage potential high. Mitigation measures recommended.	Protection successful
Plastic and steel gas pipeline	Low pressure distribution line over 3 longwall panels	Structural integrity and functionality	Damage potential for the steel pipe portions. Mitigation recommended.	Mining in progress
Lake	A large lake over 11 planned longwall panels	Land area to be submerged by water after subsidence	About 400 acres of land will be submerged or ponded	Successfully undermined
Water ponds	2 water ponds over 2 longwall panels	Stream dewatering, potential underground mine workings flooding	Possibility of dewatering is low	Accurate assessment
Streams	3 streams over 7 longwall panels	Stream dewatering, potential underground mine workings flooding	Varying potential of stream dewatering	Accurate assessment
Mine refuse facility	Over 3 longwall panels with high embankment	Feasibility of longwall mining under	Support area recommended under the embankment, feasible to mine under pond	Successfully undermined
Mine refuse facility	Over 3 longwall panels previously mined	Feasibility of building the facility over the mined panels, long-term subsidence	Effects of long-term subsidence is very minor. Construction is feasible.	Feedback not available
Mine refuse facility	Over 3 planned longwall panels with very shallow overburden	Feasibility of longwall mining under	Safety questionable. Alternative mining plans suggested.	Not yet undermined
Railroad and bridge	A railroad over 4 longwall panels	Subsidence influences and operation safety	Influences could be strong. Monitoring and Mitigations recommended	Successfully protected
Power transmission system	3 towers (80 to 120 ft tall) and one substation over two longwall panels	Integrity, stability, functionality and operation safety	Anticipated structural problem on one tower and stability problem on another	Accurate assessment
Telecommunication transmission tower	200-ft tall tower located over a longwall panels (Fig 2)	Integrity, stability, functionality	Strong influences. Mitigation measures recommended and implemented	Accurate assessment and successful protection
Highway and bridge	Highway across the end areas of 3 longwall panels	Subsidence influences	Very minor influence on highway. Questionable on bridge	Accurate assessment
Primary and secondary roads	Four roads over 8 lonwall panels	Subsidence influences	Varying degrees of influences, mitigations recommended for 2 roads	Accurate assessment

movements and deformations without being damaged (e.g., tension cable method). Mitigation measures for various structures affected by subsidence have been developed and tested in field conditions. Table 2 shows some of the structures that have been successfully protected with direct involvement of the authors.

Design of Support Area

By leaving an adequate area of coal unmined or partially mined under the structure to be protected, the surface movements and deformations in the area of the structure can be kept below the permissible level of the structure. The Pennsylvania method for designing support area is one example of applying this concept. However, the PA method over-designs the support area when mining depth is more than 350 ft. Based on a large number of collected longwall subsidence cases, a new method for designing support area has been proposed as shown in Fig. 3 (Peng and Luo, 1993) and successfully applied for two large structures (Table 2).

Mitigation Techniques for Residential Structures

A number of simple but effective mitigation measures have been frequently applied by the authors in protection of nearly 30 residential structures (Table 2). Among them, com-

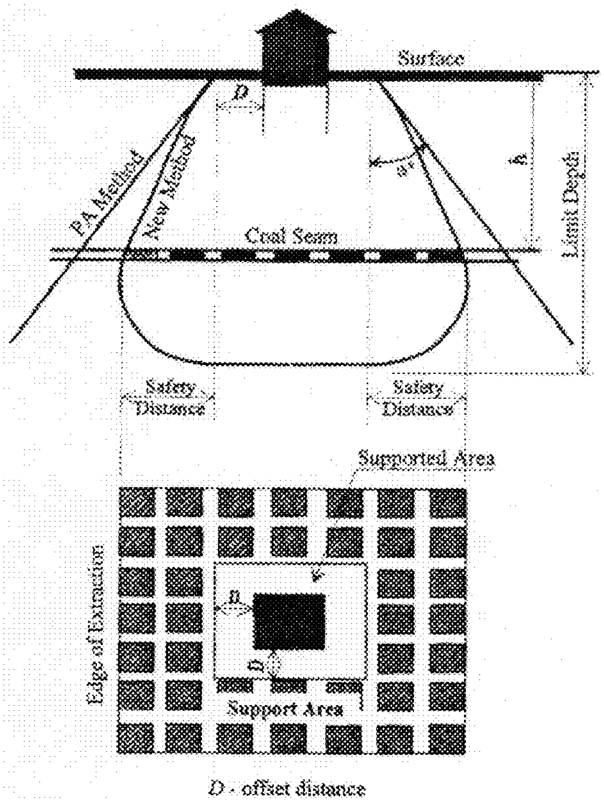

Fig. 3 A method to design support area for surface structure has been developed based on the analysis of a large number of longwall subsidence cases. The support area designed using this method is usually smaller than that using PA method

pensation trench method is used to absorb surface tension or compression that could be transmitted to the structure from its surrounding ground. This method has been proven effective to reduce problems on the structural parts that have direct contact with the subsiding ground, such as basement and foundations. *Plane-fitting method* is to protect the super-structure of a house from being damaged by the bending and twisting actions associated with subsidence process. During the implementation of this method, the house super-structure is placed on a time-dependent inclined plane so that the super-structure is free of stress while the required amount of adjustments are kept minimized. *Tension cable method* is used to strengthen the structures so that they can tolerate higher surface tension and bending. Figure 4 shows a brick house that were successfully protected using a compensation trench and two tension cables.

Mitigation Measures for Buried Pipelines

Ground subsidence process often has the potential to cause damages to buried pipelines. Assessments of subsidence influences on various buried pipelines have indicated that the strain transmitted from the surrounding soil to the pipeline is always the No. 1 source of stress on the pipeline (Luo et al., 1997). Therefore, reduction of the strain transmission is the most effective method in the protection of buried pipelines. Uncovering pipeline only in the sections where the estimated stress is higher than the permissible stress of the pipeline material can greatly reduce the pipeline stress contributed by the ground strain. Such partial uncovering method has been successfully applied in the protection of a 7,800-ft section of water supply pipeline undermined by four longwall panels (Table 2).

Mitigation Measures for Railroad

Ground subsidence is capable of causing serious problems to railroads if proper cautions are not taken. A partial

Table 2 Some Examples of Successfully Protected Structures

Structures Protected	Descriptions	Mitigation Measures Employed	Results	Monitoring Performed
Residential Structures	25 houses, 2 garages and 1 swimming pool over 19 longwall panels	plane-fitting, compensation trench, tension cable, external bracing	Very good rate of success. Figure 4 is one of the examples	Subsidence
Railroad	About 11,000 ft long over 4 longwall panels	Partial lifting	It was kept operating during subsidence. Great saving in material and labor costs	Subsidence
Railroad bridge	130 ft, three sections	A 440x510 ft^2 support area under the bridge	Bridge not affected at all	Subsidence
Water pipeline	About 7,800 ft long 12-inch steel pipeline over 4 longwall panels	Partial uncovering	Service has never been intrupted	Subsidence, strain
Overland conveyor belt system	About 1,400 ft long erected between 16 and 50 ft above ground level with a 300-ton transfer tower over a longwall panel	Uncovering support bases, loosening bolts at the bases, lateral stabilization	Despite of large surface movement, it required only some minor repairs before being put into operation again	Subsidence, strain, tilting
Telecommunication transmission tower	About 200 ft high located on the top of high mountain and between two longwall panels	Compensation trench, strengthening tower base	Despite of ground cracks observed nearby, no damage observed on the structure and service not interrupted	Visual observation
Coal refuse disposal facility	Large slurry pond with an embankment nearly 200 ft high.	A 1,390x1,930 ft^2 support area under the embankment only	The integrity, stability and functionality of the facility not affected	Subsidence

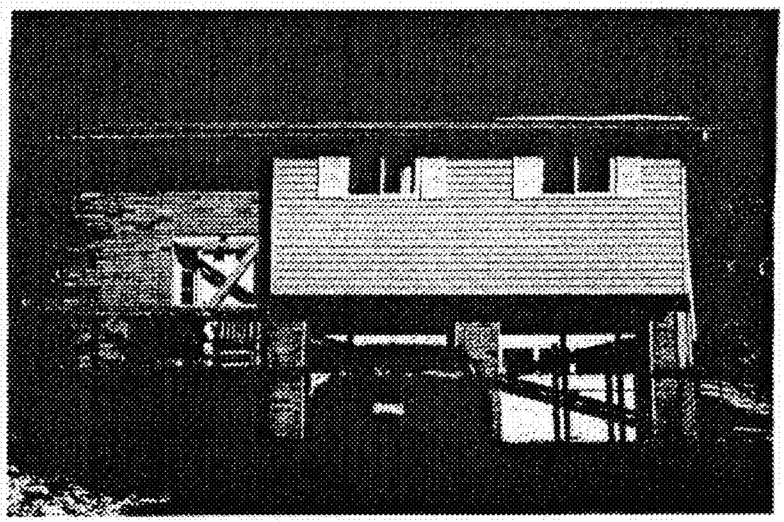

Fig. 4 This brick house was successfully protected by a compensation trench and two tension cables. The placements of the trench and cables and the required tension in the cables were determined by subsidence simulations.

lifting method has been developed. The original elevation profile of the railroad, the predicted final subsidence profile and the permissible railroad grade are considered in determining the required adjustment along the section of railroad to be affected. This method has been applied to protect a section of railroad about 11,000 ft long undermined by four longwall panels (Table 2). The maximum subsidence at the site was about 4.5 ft. Adjustment on the railroad was only recommended in some sections much shorter than the total length of the railroad affected by subsidence with the maximum adjustment being about 2.5 ft only. As a result of implementing the partial lifting method, the subsided and adjusted railroad was kept smooth for safe railroad operation while the required adjustment was kept to a minimum.

A CASE STUDY

This section shows a case of the protection of a railroad over a longwall panel. The longwall panel was 930 ft wide mining a coal seam of about 6.5 ft thick. The overburden depth at the site was about 680 ft. The layout of the railroad over the longwall panel is shown in Fig. 5. The predicted final subsidence at the site is also plotted in this figure with the maximum subsidence being about 4.2 ft which matched very well with the measurements. The elevation profile of this section of railroad before subsidence is shown in Fig. 6. Based on the predicted final subsidence, original elevation and the permissible grade of 0.7%, the final railroad profile requiring the minimum amount of vertical adjustment was determined before it was undermined. In preparation, a large proportion of the required amount of gravel to raise the railroad was shipped to the site and spread in the sections needing the most amount of adjustment. During the active subsidence period, the railroad was monitored and vertical adjustment was made accordingly. A temporary speed limit of 5 mph was also posted as a precaution. Figure 6 shows one set of recommended adjustment during the active subsidence period and the elevation profiles of the railroad before and after the implementation of the recommended adjustment. By implementing the recommended adjustment, the maximum railroad grade was reduced from about 1.0% to the permissible 0.7% (Fig. 7). The railroad service was never interrupted during the entire subsidence process. Figure 8 shows a fully loaded coal train was passing the section of subsiding and adjusted railroad.

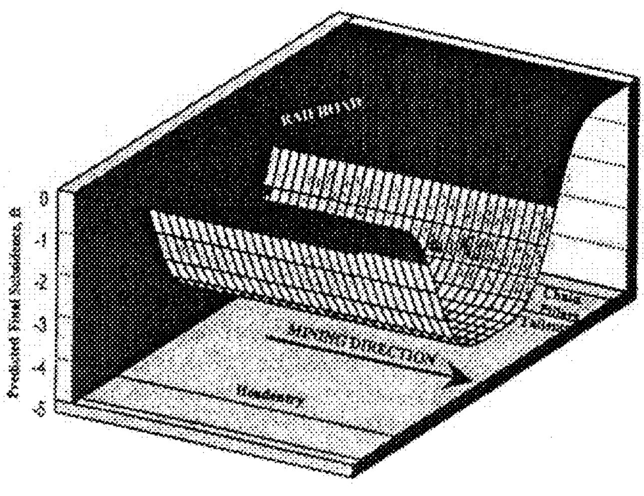

Fig. 5 Layout of the railroad over the longwall panel and predicted final surface subsidence at the site

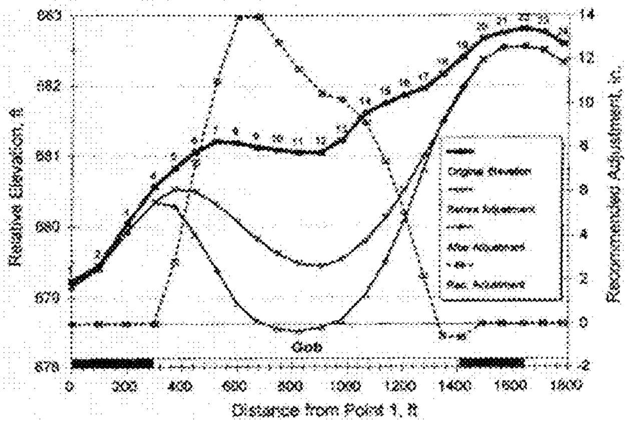

Fig. 6 Elevation profiles of the railroad and one set of recommended vertical adjustment during the active subsidence period. Using the partial lifting method, the required adjustment was kept to a minimum while the railroad was smooth.

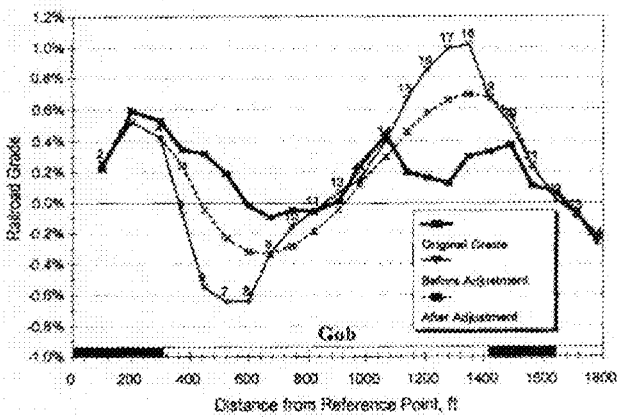

Fig. 7 Grade profiles of the subsiding railroad before and after implementing the recommended adjustement. The maximum grade of the adjusted railroad was kept within the permissible grade of 0.7%

SUMMARY

Subsidence prediction, influence assessment and damage control have come a long way. A systematic subsidence research program coupled with intensive field monitoring and extensive data collection during the past twenty years have produced vast amount of quality data and knowledge. Numerous case studies have demonstrated that using these research results, surface subsidence caused by full and high extraction mining methods and its effects can be predicted with confidence, and mitigation measures can be selected, designed and implemented successfully.

REFERENCES

Luo, Y. and S.S. Peng, 1990, "A Mathematical Model for Predicting Final Subsidence Basin in Hilly Regions," *Proc. AEG National Symposium on Mine Subsidence -- Prediction and Control*, Ed. C.D. Elifrits, Association of Engineering Geologists, pp. 223-231 (Republished in AEG Bulletins).

Luo, Y. and S.S. Peng, 1990, "A Mathematical Model for Predicting Subsidence over Chain Pillars Between Mined-out Longwall Panels," *Proc. AEG National Symposium on Mine Subsidence -- Prediction and Control*, Ed. C.D. Elifrits, Association of Engineering Geologists, pp. 247-257 (Republished in AEG Bulletins).

Luo, Y. and S.S. Peng, 1991, "Some New Findings from Surface Subsidence Monitoring over Longwall Panels," *Mining Engineering*, SME, Littleton CO, 1991 (10), pp. 1261-1264.

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Peng, S.S. and Y. Luo, 1988, "Determination of Stress Field in Buried Thin Pipelines Resulting from Ground Subsidence due to Longwall Mining," Mining Science and Technolgy, Vol. 6, pp. 205-216.

Peng, S.S. and Y. Luo, 1992, "Comprehensive and Integrated Subsidence Prediction Model - CISPM (V2.0)," *Proc. 3rd Workshop on Surface Subsidence Due to Underground Mining*, Ed. S.S. Peng, West Virginia University, Morgantown, WV, pp. 22-31.

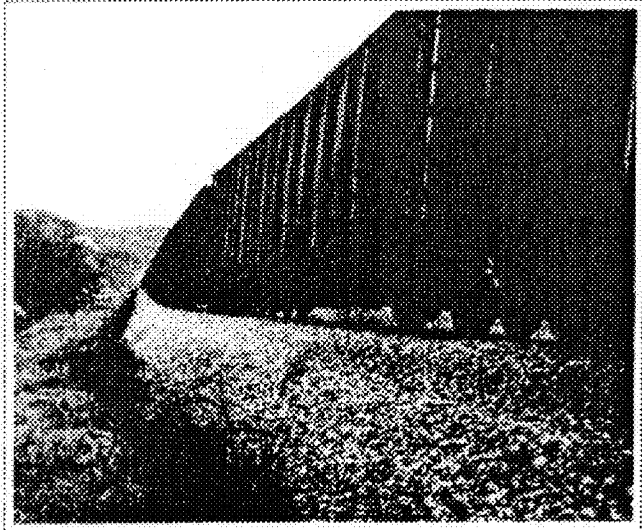

Fig. 8 This loaded coal train was passing through a section of subsiding railroad. The railroad was successfully protected using the partial lifting method.

Peng, S.S. and Y. Luo, 1993, "A New Method for Designing Support Area to Protect Surface Structures over Underground Coal Mining Areas," *AIME-SME 1993 Transactions*, Vol. 294, pp. 1927-1932.

Peng, S.S., Y. Luo and Z.M. Zhang, 1995, "Subsidence Parameters -- Their Definitions and Determination," a paper presented at 95 AIME-SME annual meeting, Denver, CO, 7 pp. (to be published in *Mining Engineering*)

ORIGINAL

ODNR-Division of Mineral Resources Management

ARP REVIEW TRACKING SHEET

APPLICANT	American Energy Corp.	**ARP #**	R-425-17
ARP SUMMARY	Revise Subsidence Control Plan		
DISTRICT	Cambridge	**APP. MANAGER**	Treva Knasel
DATE RECEIVED BY APPLICATION MANAGER			10-27-2005

	YES	NO
1. **Is the ARP a SIGNIFICANT REVISION?** *If yes, complete and attach significant ARP Cover Sheet.*		X
2. **Were there public comments and/or an informal conference requested?** *If yes, a written response must be sent to those providing comments at the time the ARP is either approved or disapproved.*		

INITIAL REVIEW

	Check applicable reviewers and indicate date(s) the ARP was distributed and comments returned	Date Sent for Review	Date Response	ACCEPTABLE YES	ACCEPTABLE NO
	Tom Hines (Soils)				
	Mike Mann (Blasting)				
	Scott Stiteler (Ownership)				
X	Engineer: Joe Noonan	11-4-2005	1-6-06		
	Hydrologist:				
	Field ES:				
	Inspector:				
	Other:				

Date Revisions Sent to Applicant	1-10-06	***Revisions Rec'd from Applicant***	5-15-06

SECOND REVIEW

	Check applicable reviewers and indicate date(s) the ARP was distributed and comments returned	Date Sent for Review	Date Response	ACCEPTABLE YES	ACCEPTABLE NO
	Jack Johannes (Soils)				
	Mike Mann (Blasting)				
	Scott Stiteler (Ownership)				
✓	Engineer: Joe Noonan	5-23-06	6-5-06		✓
	Hydrologist:				
	Field ES:				
	Inspector:				
	Other:				

Date Revisions Sent to Applicant	6-8-06	***Revisions Rec'd from Applicant***	8-24-06

Spoke w/ Melanie Murray
- Faxed eng. regist. applic.

✓ Eng: Joe Noonan 8-28-06 4-5-07 ✓

3-23-07

AEC 19779

Knasel, Treva

From: Noonan, Joe
Sent: Friday, January 06, 2006 2:44 PM
To: Knasel, Treva
Subject: AEC R-0425-17 subsidence control plan update.

R-425-17.doc

The attached file contains revision needed.

Provide a bulleted summary of the mitigation steps that will be carried out based on Dr. Luo's subsidence analysis of the water tower, electric towers and communication towers. Revise the response in the application to identify these mitigation measures.

Revise the panel layout on the permit map to match the panel layout recommended by Dr. Luo to minimize subsidence impacts on the tower bases.

The report states that a detailed survey of the anchorage of the electric towers must be done to assess the subsidence and each of the 14 towers must be assessed individually. The bottom of page 14 of the report indicates that there has not been sufficient information provided to complete the evaluation.

An engineer must certify the final mitigation plan.

January 10, 2006

Melanie Murray
American Energy Corp.
43521 Mayhugh Hill Rd.
Beallsville, OH 43716

Dear Mrs. Murray:

The Division of Mineral Resources Management completed our review of your recent Application to Revise a Permit (ARP) #R-425-17 on January 10, 2006 in which you propose to modify your permitted mining and/or reclamation plan. The following revisions are required before we can further consider your request.

A. ARP Review

1. Provide a bulleted summary of the mitigation steps that will be carried out based on Dr. Luo's subsidence analysis of the water tower, electric towers, and communication towers. Revise the response in the application to identify these mitigation measures.

2. Revise the panel layout on the permit map to match the panel layout recommended by Dr. Luo to minimize subsidence impacts on the tower bases.

3. The report states that a detailed survey of the anchorage of the electric towers must be done to assess the subsidence and each of the 14 towers must be assessed individually. The bottom of page 14 of the report indicates that there has not been sufficient information provided to complete the evaluation. Provide information.

4. An engineer must certify the final mitigation plan.

Please submit the required revisions within thirty (30) days of this letter to avoid delays in our review of your proposal. Should you require additional time, please do not hesitate to contact me. Failure to submit the required revisions in a timely manner may result in your proposal being returned without further action.

Sincerely,

Treva J. Knasel
Application Manager
Permitting, Hydrology & Bonding Section

c: Joe Noonan
John Puterbaugh
File

DNR 0081

AEC 19782

AMERICAN ENERGY CORPORATION

43521 Mayhugh Hill Road • Twp. Hwy. 88 • Beallsville, OH 43716

PHONE: (740) 926-9152
FAX: (740) 926-9138

RECEIVED
MAY 1 5 2006
DIVISION OF MINERAL
RESOURCES MANAGEMENT

May 9, 2006

Treva Knasel
Division of Mines & Reclamation
1855 Fountain Square Court
Building H-3
Columbus, Ohio 43224-1383

Dear Treva:
Enclosed is the response to the ARP revision letter dated January 10, 2006 for #R-425-17.

1. In order to prevent subsidence damage to the water tank, AEC will place two steel tension cables on the concrete base. New ¾-inch cables will be used. The cables will be placed approximately 4 inches below the top surface of the concrete base and each cable will be tensioned to approximately four tons. The cables will be installed prior to the longwall being 200 feet from the tower, and released after the longwall is further than 1000 feet from the tower.
   AEC believes that AEC's rights supersede the rights of the telecommunication and power transmission companies. AEC will notify the telecommunication and power transmission companies prior to mining under the towers. AEC expects the communication and power transmission companies to mitigate for and monitor their structures.
2. The panel layout has been revised and submitted through a separate ARP.
3. As noted earlier, AEC believes that AEC's rights supersede the rights of the power transmission company, and that it is the responsibility of the power transmission company to mitigate and monitor their structures.
4. See the enclosed document. This seal page is to be attached to the report written by Dr. Yi Luo.

Sincerely,

Melanie Murray

Melanie Murray
Civil and Environmental Engineer

OHIO DEPARTMENT OF NATURAL RESOURCES
MINERAL RESOURCES MANAGEMENT

ARP REVIEW DUE DATE LETTER 2

Applicant: AMERICAN ENERGY CORP

ARP Number: R-425-17

Summary:
Revise Subsidence Control Plan

RECEIVED
JUN - 7 2006
DIVISION OF MINERAL RESOURCES MANAGEMENT

District: CAMBRIDGE

Application Manager: Treva Knasel

Date Received by Application Manager: 10/27/2005

This sheet is to be completed by the Permitting, Hydrology, Bonding Section Application Manager and attached to any ARP documents that are being sent to technical and other staff for review. A separate sheet is to be completed for each reviewer.

Date Sent: ~~11/04/2005~~ 5/23/06 **Date Review Due:** ~~11/25/2005~~ 6/6/06

- ☐ Hydrologist:
- ☐ Inspector:
- ☐ Field Team Leader:
- ☐ Environmental Specialist:
- ☑ Engineer: Joe Noonan - N.P.
- ☐ Blasting Plan:
- ☐ Soil Scientist:
- ☐ Archaeologist:

RECEIVED
MAY 2 6 2006
By

If applicable, date ARP was put on public file:

COMMENTS: Need Ohio Eng. Cert. Attached is App. for Comity

I have reviewed the ARP documents and following this review find the material and information provided by the applicant to be:

☐ ACCEPTABLE No further revision(s) is required. The ARP is for activity that complies with current regulatory requirements

☒ UNACCEPTABLE Additional revisions are needed as outlined in the attached document.

Signature: [signature] **Date:** 6/5/2006

A4 Rev: 07/01/2001

AEC 19784

State Board of Registration for Professional Engineers and Surveyors

77 South High Street, Room 1698 • Columbus, Ohio 43215-6108
TEL +1 614 466 3650 • FAX +1 614 728 3059 • US TOLL FREE +1 877 644 6364
EMAIL pecomity@mail.peps.state.oh.us • WEB ohiopeps.org

Professional Engineer Registration by Comity

State of Ohio Minimum Requirements

The Board needs your completed application for registration, an official transcript showing your highest degree, and an application fee in US funds for $415.00 payable to **Treasurer, State of Ohio**. Your transcripts may either be included with your application or sent directly to us from your school.

After we receive your application and deposit your check, we will request verification of licensure and examinations from the appropriate Boards. You should hear from us, good news or bad, within 60 days. Feel free to email or call regarding the status of your application at any time.

If you are interested in a temporary permit to practice engineering while we are processing your application, please look at our Temporary Permit application. If you are interested in applying as a Model Law Engineer (qualified applicants get licensed in one week), please look at the Model Law Engineer Application and Instructions. Applicants who hold National Council of Engineering Examiners Certificates must complete pages 1 and 4 of the application form ENG 1011 (Rev. 10/2003) and enclose a copy of their request to NCEES for record transmittal.

Under Ohio law, an applicant who is registered and in good standing in another state may be registered in Ohio without written examination providing the applicant secured registration elsewhere by meeting requirements equal to those specified in the Ohio law at the time the applicant was registered in the state where the applicant now holds a valid certification.

1975 to present

Applicants registered after December 31, 1975 seeking registration by comity in Ohio, will require a degree in engineering of four years or more from an accredited (EAC/ABET) engineering curriculum, plus four years of Board-approved experience, or a degree of four years or more from a college curriculum in engineering (non-EAC/ABET) or a related science accepted by the Ohio Board, and eight years or more of Board-approved experience. Applicants must have passed both the Fundamentals of Engineering and Principles and Practice of Engineering examinations.

1946 to 1975

Applicants registered between January 1, 1946 and December 31, 1975 have been required to secure registration by a two-day written examination, plus eight years preparatory education and/or experience in engineering. Non-Board-approved engineering curricula degrees and related science degrees come under the twelve-year law.

1935 to 1946

Applicants registered from March 26, 1935 to December 31, 1945 were registered (a) by graduation from an approved curriculum in engineering from an accredited school, plus four years Board approved practice in engineering work, or (b) with eight years Board-approved experience, plus a two-day written examination.

Prior to 1935

Applicants registered prior to March 26, 1935 were under the "grandfather clause."

Be aware that O.R.C. Chapter 4733.16 requires almost all business firms to hold a "Certificate of Authorization" from the Board in order to provide or offer to provide engineering or surveying services in the State of Ohio.

Notice statement. The State Board of Registration for Professional Engineers and Surveyors is requesting disclosure of information that is necessary to accomplish our statutory purposes as outlined under O.R.C. Chapter 4733. Disclosure of this information is required. Failure to provide any information may result in your application not being processed.

State Board of Registration for
Professional Engineers and Surveyors
77 South High Street, Room 1698 • Columbus, Ohio 43215-6108
VOICE +1 614 466 3650 FAX +1 614 728 3059 US TOLL FREE +1 877 644 6364
EMAIL board@mail.peps.state.oh.us WEB ohiopeps.org

Application for Registration

as a Professional Engineer or Professional Surveyor or for certification as an Engineer Intern or Surveyor Intern

I, ..., hereby apply for registration in the State of Ohio and submit the following evidence and application fee as required by Ohio law.

- Required personal information, including **photograph**.
- Required evidence of education, including an **official transcript** of college credits, except for graduating seniors [see note (d) on page 3].
- Required **evidence of experience**, except for graduating seniors.
- **References** [see note (b) on page 3].
- Application **fee** to accompany application. Fees are not refundable per Ohio A.C. 4733-19-01.
- Note: If you do not appear for an examination for which you have submitted a Notice of Intention, you will be charged an additional examination fee per Ohio A.C. 4733-19-01 the next time you wish to be scheduled for an Ohio examination.

Do not file a duplicate application seeking the same registration.
The Board will keep your application permanently on file.

This application is for professional registration in the State of Ohio by:

☐ **Examination**
$25.00 application fee

Choose **only** one

Engineering
☐ Fundamentals (FE)
☐ Principles and Practice (PE)

Surveying
☐ Fundamentals (FS)
☐ Principles and Practice (PS)

☐ **Comity**
Application fees below

Choose **only** one
☐ **Professional Engineer**
$415.00 application fee
PE DISCIPLINE

☐ **Professional Surveyor**
$455.00 application fee

Your photograph REQUIRED

Passport or passport-style photograph is preferred.

What is **required** is a recognizable photograph with your face not less than ¾" wide.

Photograph must be a **permanent print**. Photocopies are not acceptable and will delay your application process.

Your name as it is to appear **officially** on your Ohio registration certificate	**Social security number**
Your email address is optional	**Birth date**
Home address OR Student college address	**Home telephone**
City / **State** Province / **ZIP** Postal Code	**Ohio county** Country
Business address OR Student permanent address	**Business telephone**
City / **State** Province / **ZIP** Postal Code	**Ohio county** Country

Notice Statement. Ohio's State Board of Registration for Professional Engineers and Surveyors is requesting disclosure of information that is necessary to accomplish our statutory purposes as outlined under Ohio R.C. Chapter 4733. Disclosure of this information is required. Failure to provide any required information may result in this application not being processed.

AEC 19786

Engineering information

		State	Date taken	Certificate number
☐ NO ☐ YES	Have you taken and passed the **Fundamentals of Engineering** examination?			
☐ NO ☐ YES	Have you taken and passed the **Principles and Practice of Engineering** examination?			

		Where granted	Certificate number
☐ NO ☐ YES	Are you now registered or have you ever been registered as a **Professional Engineer** in Ohio or in another US state or territory? Registration secured by (written examination, comity, other) Describe:		
		Date granted	Expiration date

Surveying information

		State	Date taken	Certificate number
☐ NO ☐ YES	Have you taken and passed the **Fundamentals of Surveying** examination?			
☐ NO ☐ YES	Have you taken and passed the **Principles and Practice of Surveying** examination?			

		Where granted	Certificate number
☐ NO ☐ YES	Are you now registered or have you ever been registered as a **Professional Surveyor** in Ohio or in another US state or territory? Registration secured by (written examination, comity, other) Describe:		
		Date granted	Expiration date

Disciplinary actions

☐ NO ☐ YES Have you been found guilty of any crime for which imprisonment was a possible sentence? If **yes**, attach explanation on a plain 82 x 11 sheet of paper; date and sign.

☐ NO ☐ YES Have you ever had a disciplinary action against a professional or vocational license, or registration, or had an application for same denied? If **yes**, attach explanation on a plain 82 x 11 sheet of paper; date and sign.

Formal education beyond high school

Credit claimed below must be supported by an **official** transcript from the institution. An application filed without a transcript cannot be approved until the transcript is received.

Name of institution	Years attended		Graduation date	Degree received

BOARD USE ONLY
Education
Experience
Subtotal
Additional experience
TOTAL

AEC 19787

Experience

What has been the nature and extent of your experience? Use the blank space below when answering. Any additional information pertaining to experience should be furnished on 82 x 11 plain sheets. Date and sign all additional sheets.

	Dates				Title of your position, name and location of employer, character of each employment, degree of responsibility Explain your engineering or surveying experience in sufficient detail to indicate degree of responsibilities and work performed. [See note (c)]	Time Years and months		Have your supervisor fill out the information below for each employment. If the supervisor is unavailable or unwilling to provide the information, attach a letter explaining the details.
	From		To					
	Mo.	Yr.	Mo.	Yr.		Yr.	Mo.	
1					APPLICANT'S PERCENTAGE OF TIME ENGINEERING / APPLICANT'S PERCENTAGE OF TIME SURVEYING			NAME / PHONE / EMAIL Optional / SIGNATURE / DATE / PE/PS REG. NO. / REG. STATE
2					APPLICANT'S PERCENTAGE OF TIME ENGINEERING / APPLICANT'S PERCENTAGE OF TIME SURVEYING			NAME / PHONE / EMAIL Optional / SIGNATURE / DATE / PE/PS REG. NO. / REG. STATE
3					APPLICANT'S PERCENTAGE OF TIME ENGINEERING / APPLICANT'S PERCENTAGE OF TIME SURVEYING			NAME / PHONE / EMAIL Optional / SIGNATURE / DATE / PE/PS REG. NO. / REG. STATE
4					APPLICANT'S PERCENTAGE OF TIME ENGINEERING / APPLICANT'S PERCENTAGE OF TIME SURVEYING			NAME / PHONE / EMAIL Optional / SIGNATURE / DATE / PE/PS REG. NO. / REG. STATE

Notes

(a) Experience other than college education must be listed.
(b) References need not be filled out when applying for the fundamentals' examinations.
(c) Applicants seeking surveying registration must show type and length of property surveying experience.
(d) Graduating seniors must furnish a statement signed by the dean attesting to applicant's anticipated graduation date and degree.

References REQUIRED UNLESS APPLYING FOR FUNDAMENTALS EXAMINATION

List 5 persons, at least 3 of whom are registered engineers or surveyors, from whom the Board may request information in regard to your character, experience and professional ability. Do not name your relatives or members of this Board.

1	Name	Business relationship to applicant
	Address	Occupation
2	Name	Business relationship to applicant
	Address	Occupation
3	Name	Business relationship to applicant
	Address	Occupation
4	Name	Business relationship to applicant
	Address	Occupation
5	Name	Business relationship to applicant
	Address	Occupation

Additional information for applicants

It is unlawful for a Professional Engineer or Professional Surveyor in Ohio to engage in or advertise for any work which comes under the provisions of law governing the practice of Professional Engineers and Professional Surveyors unless holding a certificate of registration and current renewal card issued by the Board. Carefully read Ohio R.C. Sections 4733.11 and 4733.19 and determine your situation before making application. Applicants must meet all education and experience qualifications 90 days prior to an examination date pursuant to Ohio A.C. 4733-9-01.

Affidavit TO BE MADE BEFORE A NOTARY PUBLIC OR OTHER OFFICIAL QUALIFIED BY LAW TO ADMINISTER OATHS

State of ______________________________

I, ____, being duly sworn, or affirmed, say that the statements made in this application are true to the best of my knowledge and belief.

____
APPLICANT SIGNATURE

Subscribed and sworn, or affirmed, to me

this ______ day of ____________________, __________.
Witness my hand and seal hereon.

____
NOTARY PUBLIC SIGNATURE

My commission expires ______________________

AEC 19789

TEMPORARY PERMIT SUPPLEMENTARY APPLICATION

State Board of Registration for Professional Engineers and Surveyors

77 South High Street, Room 1698 • Columbus, Ohio 43215-6108
TEL +1 614 466 3651 • FAX +1 614 728 3059 • US TOLL FREE +1 877 644 6364
EMAIL board@mail.peps.state.oh.us • WEB www.ohiopeps.org

Application for a Temporary Permit

Supplementary Application to practice Professional Engineering or Professional Surveying in the State of Ohio

TO THE BOARD:

If the Temporary Permit herein applied for is granted, I understand it will extend until the Board has acted upon my application for registration as a professional engineer or surveyor in Ohio by comity. I understand that my comity application must accompany this temporary permit request. If the Board determines that my application for comity registration does not meet the requirements of Ohio Revised Code Chapter 4733, the Temporary Permit will be revoked.

Comity Fees: Engineer **$415.00** • Surveyor **$455.00**. There is no additional fee for a Temporary Permit.

CONTACT INFORMATION

Social security number:

Name		Position	
Firm		Street	
City	State	ZIP	Bus. phone
Residence address: Street			Ohio county
City	State	ZIP	Res. phone

EDUCATION

College attended		
Dates attended	Degree title	Degree date

CURRENT REGISTRATION: ATTACH A COPY OF YOUR CURRENT REGISTRATION CARD(S)

	State 1	State 2	State 3
State			
Registration number			
Date registered			
Valid until			
Granted by written exam?	☐ No. ☐ Yes. Number of hours:	☐ No. ☐ Yes. Number of hours:	☐ No. ☐ Yes. Number of hours:

BOARD USE ONLY

Permit issued	Permit rejected	Fee processed

Important. Attach proof of your current registration (no more than 3). Applications without current registration proof or fees cannot be processed. This application must accompany ENG 1011 (Rev. 08/2004).

AMERICAN ENERGY CORPORATION

43521 Mayhugh Hill Road • Twp. Hwy. 88 • Beallsville, OH 43716

PHONE (740) 926-9152
FAX: (740) 926-9138

RECEIVED
MAY 15 2006
DIVISION OF MINERAL
RESOURCES MANAGEMENT

May 9, 2006

Treva Knasel
Division of Mines & Reclamation
1855 Fountain Square Court
Building H-3
Columbus, Ohio 43224-1383

Dear Treva:
Enclosed is the response to the ARP revision letter dated January 10, 2006 for #R-425-17.

1. In order to prevent subsidence damage to the water tank, AEC will place two steel tension cables on the concrete base. New ¾-inch cables will be used. The cables will be placed approximately 4 inches below the top surface of the concrete base and each cable will be tensioned to approximately four tons. The cables will be installed prior to the longwall being 200 feet from the tower, and released after the longwall is further than 1000 feet from the tower.
   AEC believes that AEC's rights supersede the rights of the telecommunication and power transmission companies. AEC will notify the telecommunication and power transmission companies prior to mining under the towers. AEC expects the communication and power transmission companies to mitigate for and monitor their structures.
2. The panel layout has been revised and submitted through a separate ARP.
3. As noted earlier, AEC believes that AEC's rights supersede the rights of the power transmission company, and that it is the responsibility of the power transmission company to mitigate and monitor their structures.
4. See the enclosed document. This seal page is to be attached to the report written by Dr. Yi Luo.

Sincerely,

Melanie Murray

Melanie Murray
Civil and Environmental Engineer

RECEIVED
JUN - 7 2006
DIVISION OF MINERAL
RESOURCES MANAGEMENT

I attest that the methodology and findings presented in this report are based upon the currently accepted principles of mining engineering. Specifically, the subsidence prediction and modeling methods used in the report have been developed and calibrated through years of research and applications on similar structures.

YI LUO
REGISTERED
16073
STATE OF
WEST VIRGINIA
PROFESSIONAL ENGINEER

Yi Luo, Ph.D., P.E.
Research Associate Professor
Department of Mining Engineering
College of Engineering and Mineral Resources
West Virginia University
Morgantown, WV 26506

Signature: ______________ Date: *January 20, 2006*

2045 Morse Rd, Building H-3
Columbus, OH 43229-6693
Phone: 614-265-6633
Fax: 614-265-7998

OHIO DEPARTMENT OF NATURAL RESOURCES
MINERAL RESOURCES MANAGEMENT

Fax

To:	Melanie Murray	**From:**	Treva Knasel
Fax:	(740) 926-9198	**Pages:**	7
Phone:		**Date:**	6/8/06
Re:	Engineer Registration Application		

☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **As Requested**

AEC 19793

Transmission Report

Date/Time: [illegible] 8-08;11:[illegible]AM
Local ID: 614 [illegible] 7960
Local Name: Mines & Reclamation
Company Logo: CONS-OMR

This document was confirmed.
(reduced sample and details below)
Document Size Letter-S

Fax

To: [illegible] From: [illegible]
Fax: [illegible] Pages: [illegible]
Phone: Date: [illegible]
Re: [illegible]

☐ Urgent ☐ For Review ☐ Please Comment ☐ Please Reply ☐ As Requested

Total Pages Scanned : [illegible] Total Pages Confirmed : [illegible]

No.	Doc	Remote Station	Start Time	Duration	Pages	Mode	Comments	Results
1	[illegible]	[illegible]	[illegible] 8-08; [illegible]AM	[illegible]	[illegible]	EC		OK [illegible]

** Notes: **

EC: Error Correct
RE: Resend
PD: Polled by Remote
MB: Receive to Mailbox
BC: Broadcast Send
MP: Multi-Poll
PG: Polling a Remote
PI: Power Interruption
CP: Completed
RM: Receive to Memory
DR: Document Removed
TM: Terminated by user
LS: Local Scan
LP: Local Print
FO: Forced Output
WT: Waiting Transfer

AEC 19794

AMERICAN ENERGY CORPORATION
43521 Mayhugh Hill Road • Twp. Hwy. 88 • Beallsville, OH 43716
PHONE: (740) 926-9152
FAX: (740) 926-9138

RECEIVED
AUG 2 4 2006
DIVISION OF MINERAL
RESOURCES MANAGEMENT

August 22, 2006

Treva Knasel
Division of Mines & Reclamation
1855 Fountain Square Court
Building H-3
Columbus, Ohio 43224-1383

Dear Treva:
Enclosed is the response to the ARP revision #R-425-17.

Enclosed is a copy of a letter from Bill Siplivy concurring with Dr. Luo's analysis.

Sincerely,

Melanie Murray

Melanie Murray
Civil and Environmental Engineer

WILLIAM J. SIPLIVY, P.E., INC.

Geotechnical Engineer

RECEIVED

AUG 2 4 2006

DIVISION OF MINERAL RESOURCES MANAGEMENT

17 August 2006

Melanie H. Murray, Civil and Environmental Engineer
American Energy Corporation
43521 Mayhugh Hill Road
Beallsville, OH 43716

Re: Report – Assessment and Mitigation of Subsidence Influences on Tower Structures Affected by Longwall Mining Operations, 12 September 2005, by Yi Luo, Ph.D, P.E., and Syd S. Peng, Ph.D.

Dear Melanie:

At your request, a review was made of referenced report. This report was submitted to the Ohio Department of Natural Resources, Division of Mines and Reclamation by American Energy Corporation in support of ARP: R-425-17.

In my opinion the report has been expertly prepared and is based upon currently accepted engineering principles regarding mine subsidence prediction and modeling analyses.

Please feel to call if there are any questions.

Sincerely,

William J. Siplivy, P.E., Inc.

William J. Siplivy

William J. Siplivy, M.S., P.E., C.P.G.
President

STATE OF OHIO
WILLIAM J. SIPLIVY
E-61015
REGISTERED PROFESSIONAL ENGINEER

Falls Towne Centre, Suite 104-2 • 2020 Front Street • Cuyahoga Falls, Ohio 44221
330-928-3267 • siplivy@sbcglobal.net

ORIGINAL

AEC 19796

43521 Mayhugh Hill Road
Twp.Hwy.88
Beallsville, Ohio 43716
Phone: 740-926-9152

American Energy Corporation

January 12, 2007

Treva Knasel
Division of Mineral Resources Management
2045 Morse RD. Bldg. 2
Columbus, Ohio 43229-6693

RECEIVED
JAN 3 0 2007

Re: Information requested by Mr. Joe Noonan

Dear Ms. Knasel:

Please find attached; a copy of the mining location map and pillar stability information requested by Mr. Joe Noonan concerning the Murray Mining Method for American Energy Corporation. Also attached is a complete copy of Dr.Luo's mitigation of subsidence influences on tower structures. Joe had asked me to send this information to you.

If you have any questions or need additional information please feel free to contact me your convenience.

Yours truly,

Fred M. Blumling
Environmental Engineer

Joe N. wanted 3-8
Fred Blumling
to send this
Stability Stuff
to me.

Spoke w/ Joe N. 3-9
* Submit ARP
— Pillar size Δ
— Safety factor Δ
— Δed equipment
using full face miner

Spoke w/ 3-9
Joe N. after
Talking w/ Fred B,
to let him know
what's going on.

left voice mail for 3-8
Joe N. — what
is this for?

per Joe N. 3-9
Full face miner,
thus Δ equipment

Spoke w/ 3-9
John Puterbaugh
re: D-425 → issuance of [illegible]
→ he had spoken
w/ Fred B. @ AEC
& told him he needed
to V/c w/ me re: ARP

* Spoke w/ 3-9
Fred Blumling
— ~~[illegible]~~ need ARP
— Fred will have
Jack Hamilton's
office to ARP.

Ellen Greer 3-9
(740) 968-4947
→ need ARP to address
- pillar size Δ
- Safety factor Δ
- Δ equipment
→ will call Joe N. for details

43521 Mayhugh Hill Road
Twp.Hwy.88
Beallsville, Ohio 43716
Phone: 740-926-9152

American Energy Corporation

January 12, 2007

Treva Knasel
Division of Mineral Resources Management
2045 Morse RD. Bldg. 2
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JAN 3 0 2007

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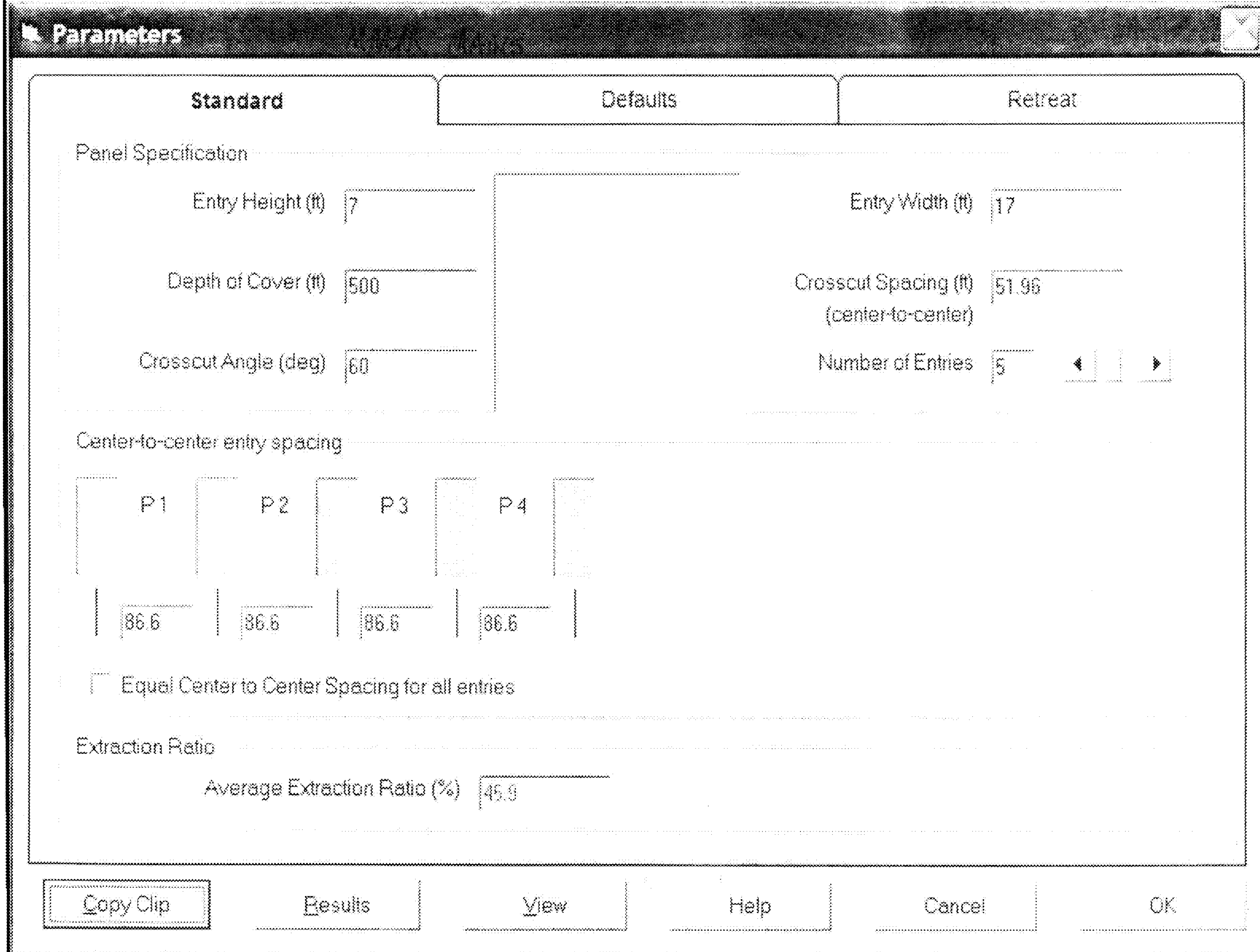
Yours truly,

Fred M. Blumling
Environmental Engineer



Parameters
Standard
Defaults
Retreat
Panel Specification
Entry Height (ft) 7
Depth of Cover (ft) 500
Crosscut Angle (deg) 60
Entry Width (ft) 17
Crosscut Spacing (ft) (center-to-center) 51.96
Number of Entries 5
Center-to-center entry spacing
P 1
P 2
P 3
P 4
86.6
86.6
86.6
86.6
Equal Center to Center Spacing for all entries
Extraction Ratio
Average Extraction Ratio (%) 45.9
Copy Clip
Results
View
Help
Cancel
OK

AEC 19800

ARMPS module build: 5.0.43
Project File: C:\Documents and Settings\rburdette\My Documents\MyNIOSH\MM1 Mains.ARM
Input Units: (ft) (psi)

[PROJECT TITLE]
MMM Mains

[PROJECT DESCRIPTION]

[DEVELOPMENT GEOMETRY PARAMETERS]
Entry Height.....................................7 (ft)
Depth of Cover...................................500 (ft)
Crosscut Angle...................................60 (deg)
Entry Width......................................17 (ft)
Number of Entries................................5
Crosscut Spacing.................................51.96 (ft)
Center to Center Distance #1.....................86.6 (ft)
Center to Center Distance #2.....................86.6 (ft)
Center to Center Distance #3.....................86.6 (ft)
Center to Center Distance #4.....................86.6 (ft)

[DEFAULT PARAMETERS]
In Situ Coal Strength............................900 (psi)
Unit Weight of Overburden........................162 (pcf)
Breadth of AMZ...................................111 (ft)
AMZ set automatically

[RETREAT MINING PARAMETERS]
Loading Condition................................DEVELOPMENT

[ARMPS STABILITY FACTORS]

DEVELOPMENT.......................2.04

[DATA ABOUT THE ACTIVE MINING ZONE (AMZ)]

AMZ Width..............................346.4 (ft)
AMZ Breadth............................111.0 (ft)
AMZ Area...............................38450.4 (ft)*(ft)
Extraction Ratio Within AMZ............0.50
Development Load on AMZ................1.56E+06 (tons)

TOTAL LOADINGS ON AMZ, INCLUDING TRANSFER FROM BARRIERS

LOAD CONDITION	ABUTMENT LOAD (tons)	LTRANSBAR (tons)	LTRANSREM (tons)	TOTAL (tons)
DEVELOPMENT	0.00E+00	0.00E+00	0.00E+00	1.56E+06

R-Factor for front abutment is the percent of the total front abutment load that is applied to the AMZ.

R-Factor for side abutment is the percent of the total side abutment load that is applied to the barrier pillar (the remainder is applied to the AMZ).

LTRANSBAR is the load transferred to the AMZ from the barrier pillar between the side and active gob if the barrier's SF is less than 1.5.

LTRANSREM is the load transferred to the AMZ from the remnant barrier between the side and active gob if the remnant's SF is less than 1.5.

[PILLAR PARAMETERS]

PILLAR	ENTRY CENTER (ft)	MINIMUM DIMENSION (ft)	MAXIMUM DIMENSION (ft)
1	86.60	28.00	80.37
2	86.60	28.00	80.37
3	86.60	28.00	80.37
4	86.60	28.00	80.37

PILLAR	AREA (ft)*(ft)	STRENGTH (psi)	LOAD-BEARING CAPACITY (tons)
1	2.25E+03	2.29E+03	3.72E+05
2	2.25E+03	2.29E+03	3.72E+05
3	2.25E+03	2.29E+03	3.72E+05
4	2.25E+03	2.29E+03	3.72E+05

TOTAL LOAD-BEARING CAPACITY OF PILLARS WITHIN AMZ: 3.18E+06 (tons)

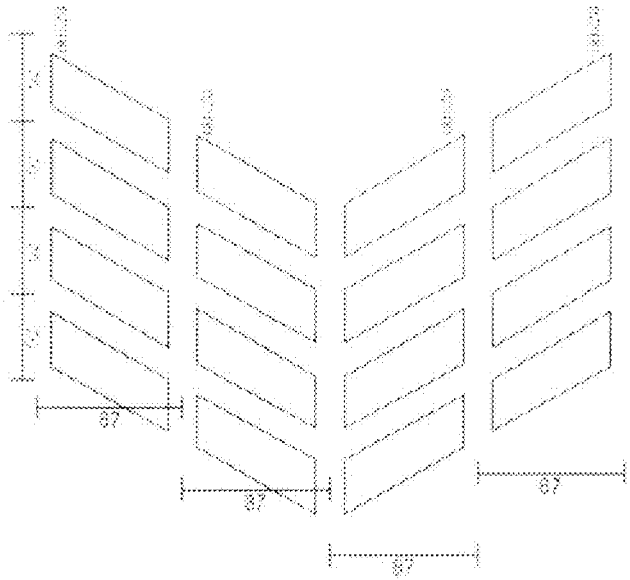
To view the distribution of Pillar Load Bearing Capacity
select 'View Plots->Settings->Pillar Load Bearing Capacity'

[BARRIER PILLAR PARAMETERS]
none

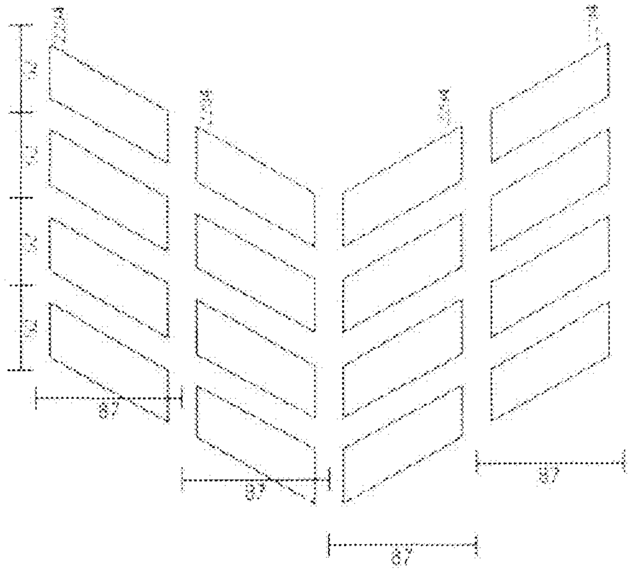
[STRESS ON INDIVIDUAL PILLARS WITHIN THE AMZ]

DEVELOPMENT STRESSES.............................1125 (psi)

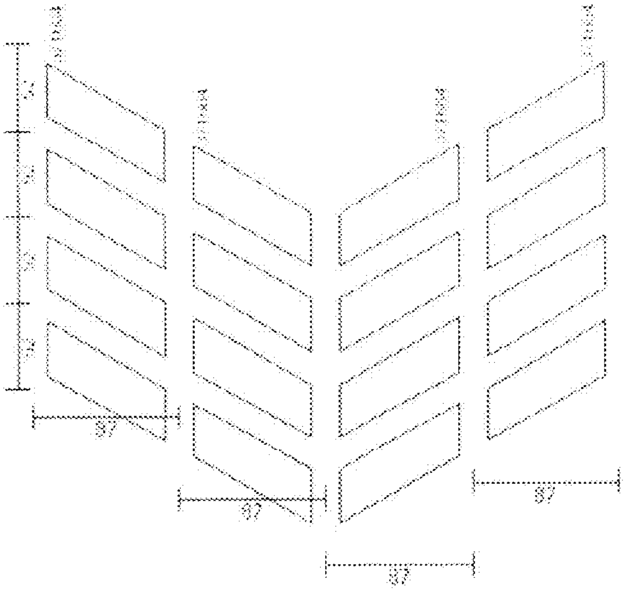
ARMPS: Actual Pillar Dimensions (width*length, ft). Entries shown from left to right.



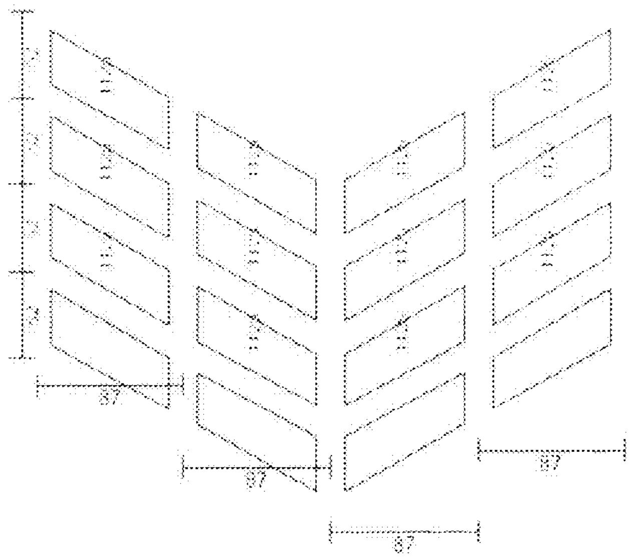
ARMPS: Unit Pillar Strength (psi). Entries shown from left to right



ARMPS: Pillar Load Bearing Capacity (tons)/(ft). Entries shown from left to right



ARMPS Individual Pillar Stresses - Total (psi) Entries shown from left to right



Stability Factors

Stability factors (SF) are obtained by dividing the total load-bearing capacity of the AMZ by the total load applied to it.

The next, critical step is the interpretation of the SF. The ARMPS method has been verified through back analysis of pillar recovery case histories. To date, more than 250 case histories have been obtained from 10 states, almost all from mine visits. They cover an extensive range of geologic conditions, roof rock cavability characteristics, extraction methods, depths of cover, and pillar geometries. Ground conditions in each case history have been categorized as being either satisfactory or unsatisfactory. Pillar failures responsible for unsatisfactory conditions included:

- Pillar squeezes;
- Massive pillar collapses, usually accompanied by airblasts, and/or;
- Coal pillar bumps.

Pillar squeezes account for approximately two-thirds of the failures in the data base. There were 14 sudden collapses, which in every case occurred when the ARMPS SF was less than 1.5 and where the pillar width-to-height ratio was less than 3.0. All but three of the 17 bumps occurred when the depth of cover exceeded 1250 ft (400m). Most of the 5 failures caused by floor heave occurred when the ARMPS SF was greater than 1.5. Preventing these types of failures clearly requires evaluation of the roof and floor strength in addition to the ARMPS SF.

Figure 5 shows that when the depth of cover was less than 650 ft (200m), 88% of the failures occurred when the ARMPS SF was less than 1.5. In contrast, the ARMPS SF was greater than 1.5 in 78% of the successes.

Chase et al (2002) studied the cases histories where the depth of cover exceeded 650 ft (200m). They concluded that lower ARMPS SF's can be successfully employed, and that stronger roof may also reduce the necessary ARMPS SF. Chase et al. also found that when the depth of cover exceeds 1000 ft (300 m), the use of substantial barrier pillars also increases the likelihood of success. Their findings are summarized in the table below:

Table 1. Pillar design considerations

Immediate roof rock quality	Weak and intermediate roof strength	Strong roof
ARMPS SF		
650 ft $<$ H $\leq$ 1,250 ft	$1.5 - \frac{(H-650)}{1000}$	$1.4 - \frac{(H-650)}{1000}$
1,250 $<$ H $\leq$ 2,000 ft	0.9	0.8
Barrier pillar SF		
H $>$ 1,000 ft	≥ 2.0	≥ 1.5[1] ≥ 2.0[2]

[1]Nonbump prone ground
[2]Bump prone ground

Other Factors Affecting Stability Factors

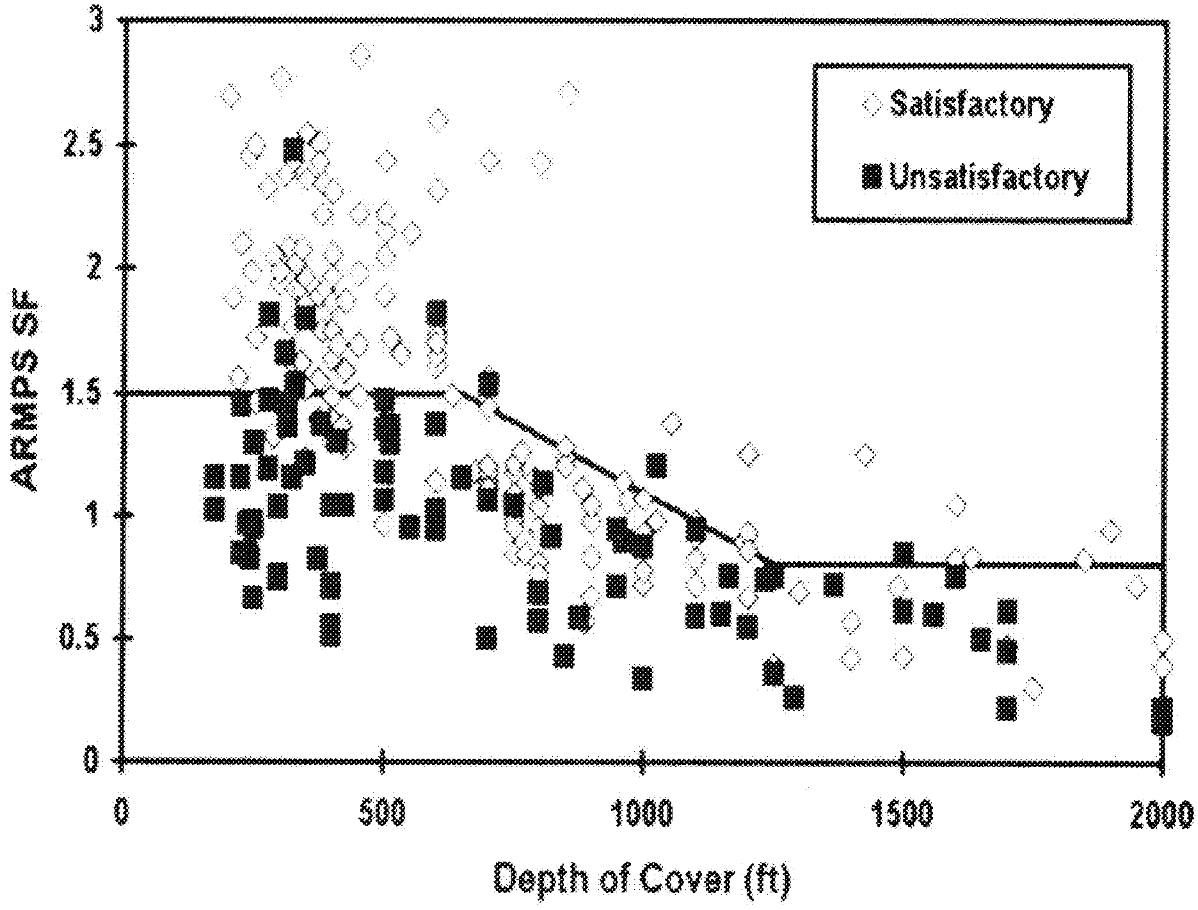
Coal strength: An extensive database of laboratory tests of the strength of coal was compiled by Mark and Barton (1997). When compared with the ARMPS database, no correlation was found between coal strength and pillar strength.

Seam height: A plot of seam height against ARMPS SF shows no correlation (Figure 10).

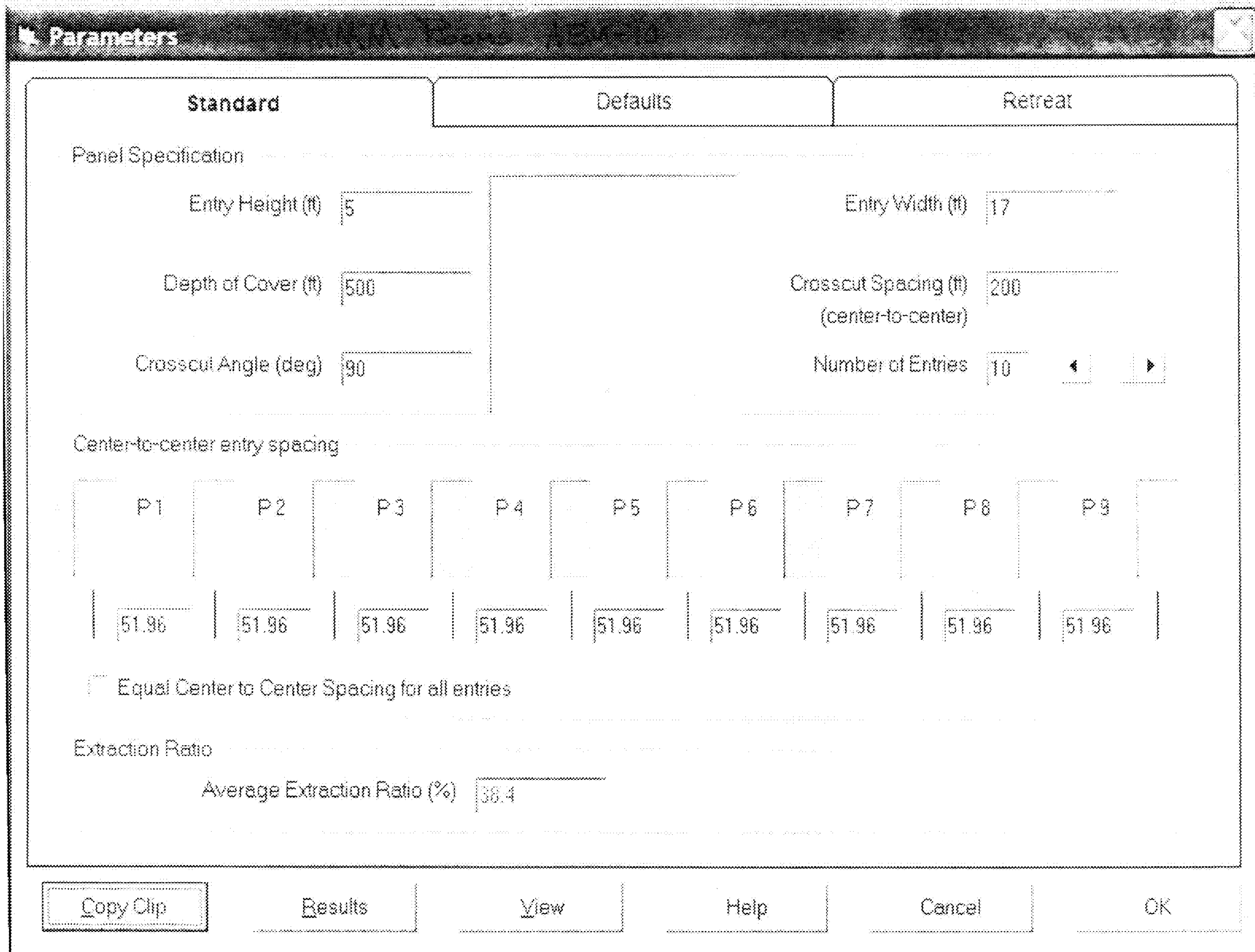
Roof Geology: A detailed study of pillar performance was conducted at a southern West Virginia mining complex. More than 50 case histories were collected. Analysis showed that satisfactory conditions were more likely to be encountered under shale roof than massive sandstone (Figure 11 and Figure 12). The implication is that better caving occurs with shale, resulting in lower pillar loads.

ARMPS appears to provide good first approximations of the pillar sizes required to prevent pillar failure during retreat mining. In an operating mine, past experience can be directly incorporated into ARMPS. ARMPS stability factors can be back-calculated for both successful and unsuccessful areas. Once a minimum ARMPS SF has been shown to provide adequate ground conditions, that minimum should be maintained in subsequent areas as changes occur in the depth of cover, coal thickness, or pillar layout. In this manner ARMPS can be calibrated using site-specific experience.

Figure 5



Satisfactory
Unsatisfactory
ARMPS SF
Depth of Cover (ft)
0
0.5
1
1.5
2
2.5
3
0
500
1000
1500
2000


Parameters
Standard
Defaults
Retreat
Panel Specification
Entry Height (ft) 5
Entry Width (ft) 17
Depth of Cover (ft) 500
Crosscut Spacing (ft) (center-to-center) 200
Crosscut Angle (deg) 90
Number of Entries 10
Center-to-center entry spacing
P1
P2
P3
P4
P5
P6
P7
P8
P9
51.96
51.96
51.96
51.96
51.96
51.96
51.96
51.96
51.96
Equal Center to Center Spacing for all entries
Extraction Ratio
Average Extraction Ratio (%) 38.4
Copy Clip
Results
View
Help
Cancel
OK

AEC 19811

```
ARMPS module build:  5.0.43
Project File: C:\Documents and Settings\rburdette\My Documents\MyNIOSH\MDN Rooms ABM-10.ARM
Input Units:  (ft) (psi)

[PROJECT TITLE]


[PROJECT DESCRIPTION]


[DEVELOPMENT GEOMETRY PARAMETERS]
Entry Height.........................................5 (ft)
Depth of Cover.......................................500 (ft)
Crosscut Angle.......................................90 (deg)
Entry Width..........................................17 (ft)
Number of Entries....................................10
Crosscut Spacing.....................................200 (ft)
Center to Center Distance #1.........................51.96 (ft)
Center to Center Distance #2.........................51.96 (ft)
Center to Center Distance #3.........................51.96 (ft)
Center to Center Distance #4.........................51.96 (ft)
Center to Center Distance #5.........................51.96 (ft)
Center to Center Distance #6.........................51.96 (ft)
Center to Center Distance #7.........................51.96 (ft)
Center to Center Distance #8.........................51.96 (ft)
Center to Center Distance #9.........................51.96 (ft)

[DEFAULT PARAMETERS]
In Situ Coal Strength................................900 (psi)
Unit Weight of Overburden............................162 (pcf)
Breadth of AMZ.......................................111 (ft)
AMZ set automatically

[RETREAT MINING PARAMETERS]
Loading Condition....................................DEVELOPMENT

[ARMPS STABILITY FACTORS]

DEVELOPMENT..........................4.11



[DATA ABOUT THE ACTIVE MINING ZONE (AMZ)]

AMZ Width..............................467.6 (ft)
AMZ Breadth............................111.0 (ft)
AMZ Area...............................51908.0 (ft)*(ft)
Extraction Ratio Within AMZ............0.38
Development Load on AMZ................2.10E+06 (tons)


TOTAL LOADINGS ON AMZ, INCLUDING TRANSFER FROM BARRIERS
          LOAD        ABUTMENT      LTRANSBAR     LTRANSREM        TOTAL
     CONDITION    LOAD (tons)        (tons)        (tons)         (tons)
   DEVELOPMENT       0.00E+00      0.00E+00      0.00E+00       2.10E+06

R-Factor for front abutment is the percent of the total
front abutment load that is applied to the AMZ.

R-Factor for side abutment is the percent of the total
side abutment load that is applied to the barrier pillar
(the remainder is applied to the AMZ).

LTRANBAR is the load transferred to the AMZ from the
barrier pillar between the side and active gob if the
barrier's SF is less than 1.5.
```

LTRANSREN is the load transferred to the AMZ from the remnant barrier between the side and active gob if the remnant's SF is less than 1.5.

[PILLAR PARAMETERS]

PILLAR	ENTRY CENTER (ft)	MINIMUM DIMENSION (ft)	MAXIMUM DIMENSION (ft)
1	51.96	34.96	183.00
2	51.96	34.96	183.00
3	51.96	34.96	183.00
4	51.96	34.96	183.00
5	51.96	34.96	183.00
6	51.96	34.96	183.00
7	51.96	34.96	183.00
8	51.96	34.96	183.00
9	51.96	34.96	183.00

PILLAR	AREA (ft)*(ft)	STRENGTH (psi)	LOAD-BEARING CAPACITY (tons)
1	6.40E+03	3.76E+03	1.73E+06
2	6.40E+03	3.76E+03	1.73E+06
3	6.40E+03	3.76E+03	1.73E+06
4	6.40E+03	3.76E+03	1.73E+06
5	6.40E+03	3.76E+03	1.73E+06
6	6.40E+03	3.76E+03	1.73E+06
7	6.40E+03	3.76E+03	1.73E+06
8	6.40E+03	3.76E+03	1.73E+06
9	6.40E+03	3.76E+03	1.73E+06

TOTAL LOAD-BEARING CAPACITY OF PILLARS WITHIN AMZ: 8.65E+06 (tons)

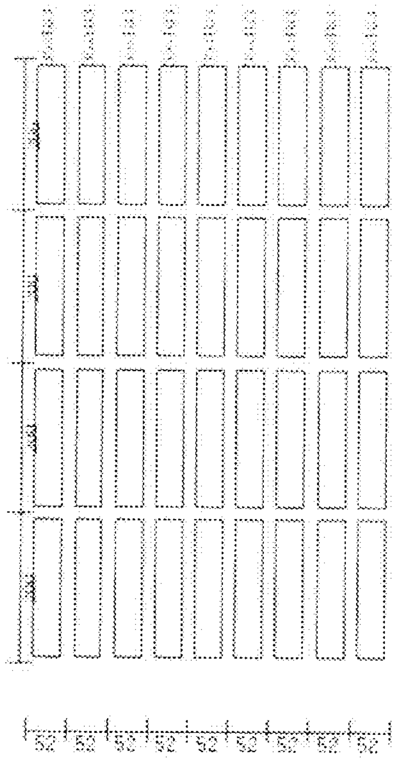
To view the distribution of Pillar Load Bearing Capacity select 'View Plots->Settings->Pillar Load Bearing Capacity'

[BARRIER PILLAR PARAMETERS]
none

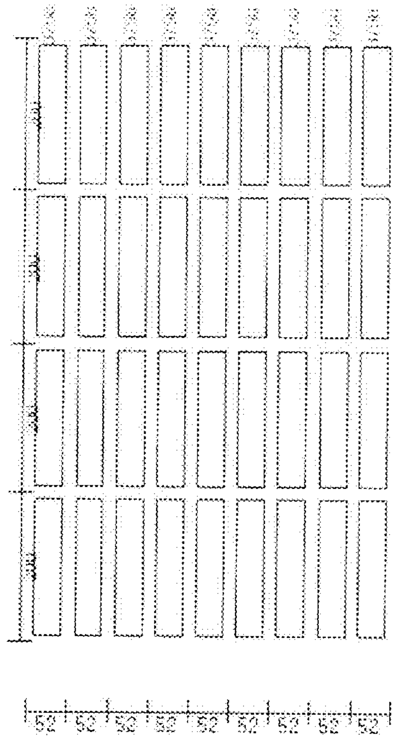
[STRESS ON INDIVIDUAL PILLARS WITHIN THE AMZ]

DEVELOPMENT STRESSES..............................914 (psi)

ARMPS: Actual Pillar Dimensions (width*length, ft). Entries shown from left to right.

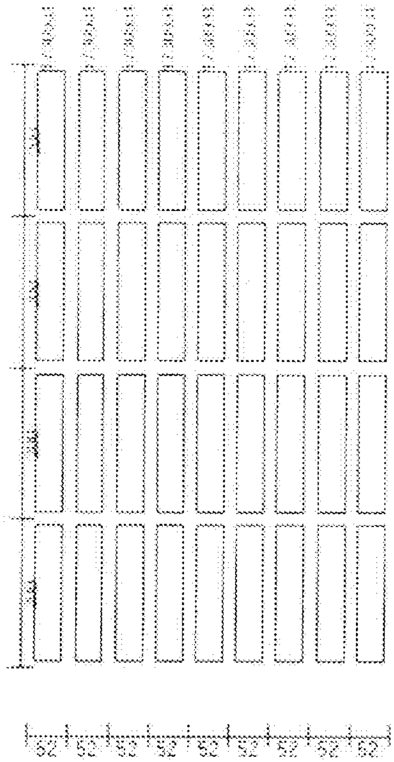


ARMPS: Unit Pillar Strength (psi). Entries shown from left to right

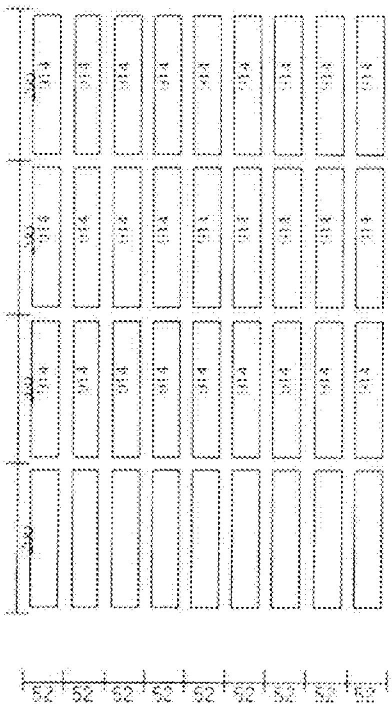


AEC 19815

ARMPS Pillar Load Bearing Capacity (tons)/(ft) Entries shown from left to right



ARMPS: Individual Pillar Stresses - Total (psi). Entries shown from left to right

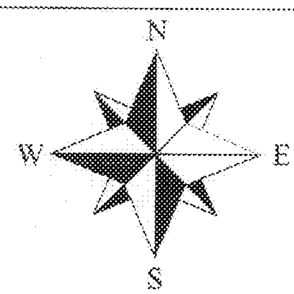


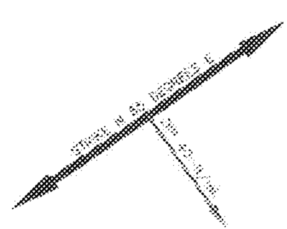
AEC 19817

INSTITUTIONAL BUILDING
SCHOOL
CHURCH
COMMERCIAL/BUSINESS BUILDING
ROADS
UTILITY LINE
PROPERTY LINE
EXISTING WATER IMPOUNDMENT
PERENNIAL STREAM
INTERMITTENT STREAM
CONSTRUCTED DRAINWAY
DIRECTION OF FLOW
PERMIT AREA = 4957.3 ACRES
HYDROLOGIC BOUNDARY (1000')
(S) SURFACE OWNER
(C) COAL OWNER
(L) LESSEE
PUBLIC WATER LINE
U- UPSTREAM SAMPLING STATION
D- DOWNSTREAM SAMPLING STATION
WL- DRILLED WELL (LOG AVAILABLE)
W- DRILLED WELL (NO LOG AVAILABLE)
DW- DUG WELL
DS- DEVELOPED SPRING
S- UNDEVELOPED SPRING
P- WATER IMPOUNDMENT
BACKGROUND SAMPLING STATION
DM- DEEP MINE ENTRY (WATER DISCHARGE)
DEEP MINE ENTRY
PERMIT D-1159
PERMIT D-0425
MONITORING STATION
E E HIGH VOLTAGE TRANSMISSION LINE
4-LEG TOWER
3-LEG TOWER
CEMETARY
G DUKE ENERGY GAS TRANSMISSION LINES
AREA OF FULL EXTRACTION

MAXIMUM EXTRACTION RATIOS: 4.5 SECTION MAINS=52% ROOMS=44%
SOUTH MAINS=37% GATES=37% LONGWALL=100%

EXTRACTION HEIGHTS: CM SECTIONS: 4.0' - 7.0'
LONGWALL: 5.7' - 5.9'





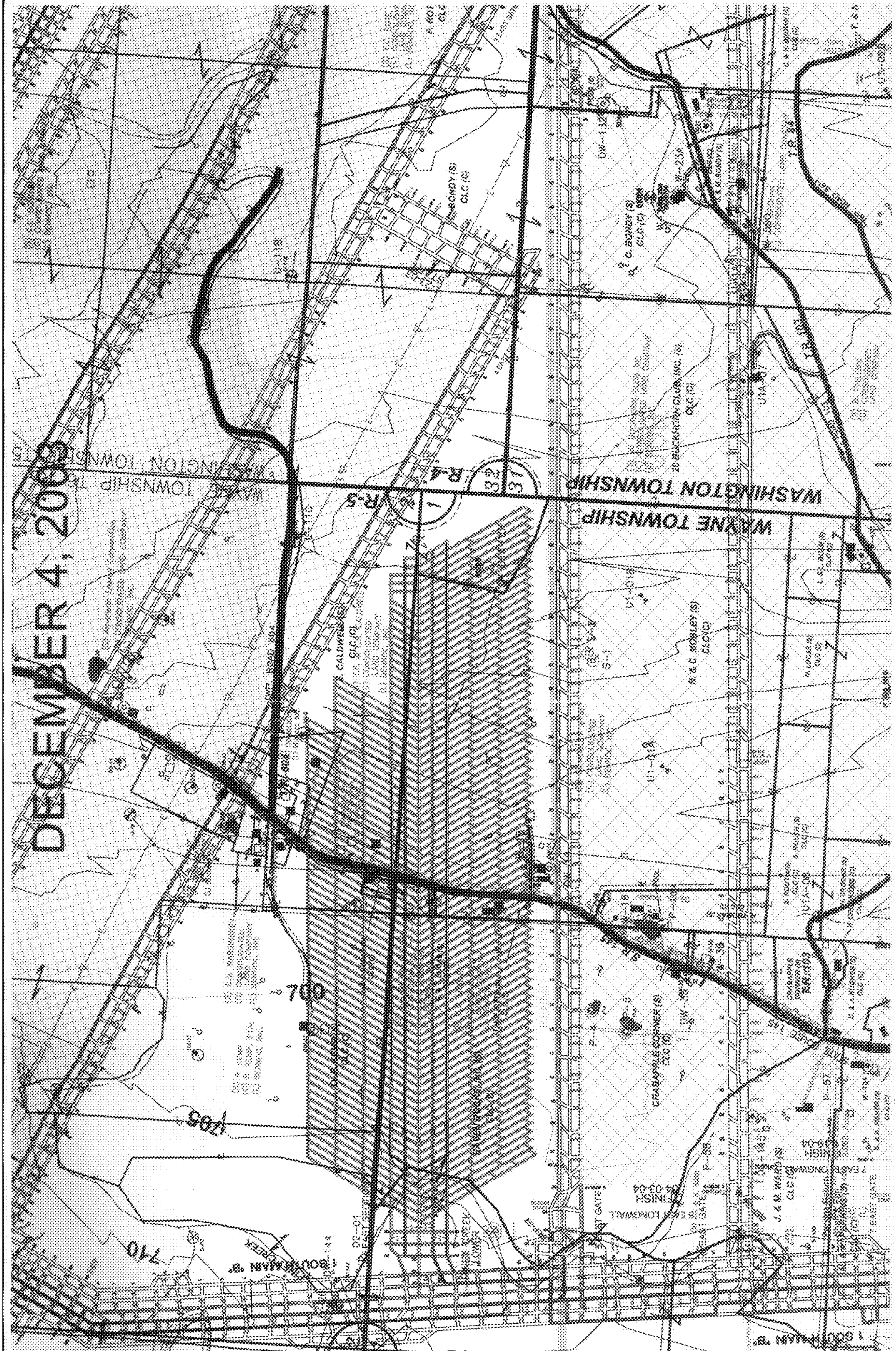
STRIKE AND DIP

0' 500' 1000' 1500'

DRAWN BY	DATE	DRAWN BY	DATE
RTD	5-23-01	SGM	12-9-03
RTD	2-12-02	SGM	10-28-04
RLB	12-01-02	TLB	10-25-05
TLB	10-06-06		

I, THE UNDERSIGNED, HEREBY CERTIFY THAT THIS MAP OF THE AMERICAN ENERGY CORPORATION'S CENTURY MINE IS CORRECT AND SHOWS ALL THE INFORMATION REQUIRED BY SECTION 1563.03 OF THE REVISED CODE AND COVERS THE PERIOD ENDING 11 October 2006

AEC 19818


DECEMBER 4, 2003
WASHINGTON TOWNSHIP
WAYNE TOWNSHIP
700
705
710

43521 Mayhugh Hill Road
Twp.Hwy.88
Beallsville, Ohio 43716
Phone: 740-926-9152

American Energy Corporation

February 5 2007

Treva Knasel
Division of Mineral Resources Management
2045 Morse RD. Bldg. 2
Columbus, Ohio 43229-6693

RECEIVED
FEB - 7 2007
DIVISION OF MINERAL RESOURCES MANAGEMENT

Re: ARP D-0425 Subsidence Mitigation Plan

Dear Ms. Knasel:

Please find attached our ARP for the above permit regarding Assessment and Mitigation of Subsidence Influences on Tower Structures Affected by Long wall Mining operations. This plan was submitted in the original permit but did not have an Ohio Professional Engineer seal for Ohio. The plan has been submitted with the proper seal.

If you have any questions or need additional information please feel free to contact me your convenience.

Yours truly,

Fred M. Blumling
Environmental Engineer

43521 Mayhugh Hill Road
Twp.Hwy.88
Beallsville, Ohio 43716
Phone: 740-926-9152

American Energy Corporation

March 12, 2007

Treva Knasel
Division of Mineral Resources Management
2045 Morse RD. Bldg. 2
Columbus, Ohio 43229-6693

Re: ARP R-425-17

Dear Ms. Knasel:

Please find enclosed (3) copies and (1) one original copy of the first page for the above ARP 425-17.

I should have Dr. Lou's data by the end of this week.

If you have any questions or need additional information please feel free to contact me your convenience.

Yours truly,

Fred M. Blumling

Fred M. Blumling
Environmental Engineer

RECEIVED
MAR 2 0 2007
DIVISION OF MINERAL
RESOURCES MANAGEMENT

43521 Mayhugh Hill Road
Twp.Hwy.88
Beallsville, Ohio 43716
Phone: 740-926-9152

American Energy Corporation

March 20, 2007

Treva Knasel
Division of Mineral Resources Management
2045 Morse RD. Bldg. 2
Columbus, Ohio 43229-6693

RECEIVED
MAR 23 2007
DIVISION OF MINERAL RESOURCES MANAGEMENT

Re: ARP R-425-17

Dear Ms. Knasel:

Please find enclosed (3) copies and (1) one original signed copy of Dr. Lou's Assessments and Mitigation of Subsidence Influences of Tower Structures Affected by Longwall Mining Operations.

If you have any questions or need additional information please feel free to contact me your convenience.

Yours truly,

Fred M. Blumling
Environmental Engineer

ARP REVIEW DUE DATE LETTER 4

Applicant: AMERICAN ENERGY CORP **ARP Number:** R-425-17

Summary:
Remove a Condition of Permit
Revise Subsidence Control Plan

RECEIVED
APR - 4 2007
BY

District: CAMBRIDGE

Application Manager: Treva Knasel

Date Received by Application Manager: 10/27/2005

This sheet is to be completed by the Permitting, Hydrology, Bonding Section Application Manager and attached to any ARP documents that are being sent to technical and other staff for review. A separate sheet is to be completed for each reviewer.

Date Sent: ~~11/04/2005~~ 4/2/07 **Date Review Due:** ~~11/25/2005~~ 4/16/07

RECEIVED
APR - 9 2007
DIVISION OF MINERAL RESOURCES MANAGEMENT

- ☐ Hydrologist:
- ☐ Inspector:
- ☐ Field Team Leader:
- ☐ Environmental Specialist:
- ☑ Engineer: Joe Noonan
- ☐ Blasting Plan:
- ☐ Soil Scientist:
- ☐ Archaeologist:

If applicable, date ARP was put on public file: __________

COMMENTS:

I have reviewed the ARP documents and following this review find the material and information provided by the applicant to be:

☒ ACCEPTABLE No further revision(s) is required. The ARP is for activity that complies with current regulatory requirements

☐ UNACCEPTABLE Additional revisions are needed as outlined in the attached document.

Signature: Joseph Noonan [redacted] 4/5/2007

A4 Rev: 07/01/2001

AEC 19823